HANDLING FLORIDA ORANGES IN PALLET BOXES

An Interim Report

Marketing Research Report No. 529

UNITED STATES DEPARTMENT OF AGRICULTURE
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Agricultural Research Service and
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in cooperation with the
Citrus Experiment Station of the
FLORIDA AGRICULTURAL EXPERIMENT STATION

PREFACE

This interim report deals with one season of research on improved methods, devices, equipment, and facilities for the conditioning, handling, and preparation for market of citrus fruits, being conducted under a cooperative research program by the United States Department of Agriculture and the Florida Agricultural Experiment Station. Replication of the research is proceeding.

Fifty to seventy-five million boxes of fruit are harvested and marketed annually in Florida fresh citrus operations. Because of the importance of more efficient and economical handling systems for moving this fruit from the picking operation to the packing line, information developed from an experimental pallet box system of handling and degreening fresh fruit is being made available before completion of the research.

Grove and packinghouse facilities and fruit were provided by S. O. Chase, Jr., Chase and Company, Sanford, Florida, and acknowledgment is made to him, Robert Carter, John Malloy, and the entire staff of Chase and Company for their cooperation in making this research effort possible.

Clark Equipment Company, through Whitmore Industrial Trucks; Love Manufacturing Company; Raymond Corporation, through J. K. Kessler and Associates; Pounds Motor Company; and Food Machinery and Chemical Corporation made equipment and material available for the tests and advised the research personnel on its use. Elberta Crate and Box Company provided pallet boxes of one type for the tests.

A. H. Spurlock, agricultural economist, Agricultural Economics Department, Florida Agricultural Experiment Station, advised on the economic analysis, and W. G. Grizzell, industrial engineer, Agricultural Marketing Service, United States Department of Agriculture, assisted in obtaining and analyzing time study data on forklift truck operations.

Friday Tractor Company; Lift Tools, Inc.; General Box Company; and Peterson Industries cooperated in relation to equipment used.

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HANDLING FLORIDA ORANGES IN PALLET BOXES

Compiled by W. Grierson, associate chemist 1/

SUMMARY

The first year's study indicated that equipment for handling pallet boxes can be operated effectively in Florida citrus groves which have the proper tree spacing and suitable soil conditions.

In the pallet-box system, supervision of the picking crew and accounting for fruit picked are more efficient than with field boxes. Reaction of the pickers has been favorable. Degreening results for fruit in pallet boxes were equal to or better than for fruit in field boxes. (Degreening is a process of altering the skin color of oranges by exposure to ethylene gas, or by other methods.) Where changes are needed to adapt existing degreening facilities for use with pallet boxes they will normally be less costly than constructing bulk degreening bins for an equivalent capacity.

The pallet-box system for handling fresh oranges from the picker to the packing line showed much promise for cost reduction and minimum mechanical injury to fruit, compared with the field-box system. Pallet boxes permit handling fruit in unit loads, yet allow the fruit to stay in the same container in which it was deposited from the picker's bag until it is dumped into the packing line.

At an annual volume of 500,000 field boxes, savings of $23,400 per year over the conventional field-box system are possible with the pallet-box system. For an annual volume of 200,000 field boxes, the corresponding savings would be $9,640 per year with the pallet-box system.

Existing flatbed trucks and semitrailers can be shifted to transporting pallet boxes instead of field boxes without any change in the equipment. Tractor forklift equipment acquired for the handling of pallet boxes can be used for other purposes, including grove care operations, by temporarily detaching parts of the lift equipment.

1/ This report was compiled in its final form by Joseph F. Herrick, Jr., marketing research analyst, Transportation and Facilities Res. Div., Agr. Mktg. Serv., from material prepared by W. Grierson, Earl K. Bowman, G. E. Yost, Jordan Levin, Scott L. Hedden, and George L. Capel. Dr. Grierson, formerly associate chemist, Fla. Citrus Expt. Sta., was responsible for the quality evaluation and degreening studies. Mr. Bowman, industrial engineer and Mr. Yost, agricultural engineer, Transportation and Facilities Res. Div., Agr. Mktg. Serv., Gainesville, Fla., were responsible for the transportation and packinghouse phase. Mr. Levin and Mr. Hedden, agricultural engineers, Agr. Engin. Res. Div., Agr. Res. Serv., were responsible for the grove operation. Dr. Capel, formerly agricultural economist, Mktg. Econ. Div., Econ. Res. Serv. and Agr. Econ. Dept., Fla. Univ., was responsible for the cost analysis and economic comparisons.

Valuable flexibility is provided by pallet boxes because they can be used effectively by either small or large fresh fruit firms and fruit can readily be kept in separate lots for any reason.

BACKGROUND

Traditionally, Florida citrus has been handled in wooden "field boxes," two-compartment containers of 2.23 U. S. bushels' capacity. This container was first introduced in 1875 and has continued in use virtually unaltered for 85 years. In the cannery trade it has been superseded by the bulk-handling method in which oranges and grapefruit are hauled in bulk in trucks in loads up to 500 equivalent boxes (1,100 bushels). Most types of citrus fruit are well suited to such handling in bulk to the cannery and the method has been adapted on a limited scale for somewhat smaller loads for successful fresh fruit handling of oranges and grapefruit. However, a major stumbling block for this bulk method has been that throughout much of the year, citrus fruits have to be degreened (altering the skin color) with ethylene gas for 1 to 3 days prior to being put through the packinghouse. A Citrus Experiment Station project, with U. S. Department of Agriculture support, developed a method of degreening in bulk (11, 12, 13). 2/ However, the initial cost is high and it is not practical when many small lots of citrus have to be kept separate. Because of these factors the bulk handling system has not been as widely adopted as was first expected.

In recent years, it has become apparent that there is a place for a bulk handling system for those companies which are not able to finance the high initial costs of changing over to a full bulk system or for which managements are unwilling to "pool" various lots of fruit in their operation. (A system of sampling the fruit when it is received at the packinghouse would still make full bulk handling practicable, but it is not used in this district for fresh citrus fruit and packers have shown no enthusiasm for such a system.)

Pallet boxes have already proved extremely successful in various deciduous fruit operations both in the United States and throughout the world (17). The obvious approach was to utilize this experience and try to adapt the method to fresh Florida citrus fruit.

For handling tangerines and other tender fruit, pallet boxes could open the way to increased efficiency. Further attention will be directed to this point as the research continues.

The main problem was in learning how to deal with differences in handling citrus in Florida and apples in Michigan and Washington with a pallet-box system. At the time this study was undertaken much information was already available on handling apples in pallet boxes and commercial acceptance of the method was a reality with the Michigan and Washington apple industry (6, 17). The principal departure lies in the differences in soil types between a Florida citrus grove and an apple orchard. These groves are of light sand, usually with very little ground cover and slightly sloping, except on the steeper land surrounding many of the numerous lakes.

2/ Figures underscored in parenthesis refer to Literature Cited, p.36.

The major difference in packinghouse operations is the necessity for the degreening operation. A previous investigation showed that oranges could be degreened in pallet boxes (18). A new type of degreening room was designed and is proving very efficient for field boxes (2), but at the time this study was undertaken it had not yet been tested for pallet boxes.

The duration of the picking season is drastically different from that of apples; Florida oranges and grapefruit usually are harvested over a period of 8 months starting in late September and continuing into May. This affects operations costs, especially as previous pallet box experience has been largely on crops picked over a short period of about 2 months or less.

FACILITIES AND EQUIPMENT USED FOR TESTS

Facilities used for the tests were far from ideal. The packinghouse was a very old one that had been remodeled many times. The general layout is shown in figure 1. Floor strength, ceiling clearances, and work spaces were not the best. On the other hand, the groves used were possibly more favorably suited for the use of mechanical equipment than many that might be encountered. The groves used in this study were 10 to 15 years old, were bearing rather heavily, and yet were not so overcrowded as to make the use of the equipment difficult.

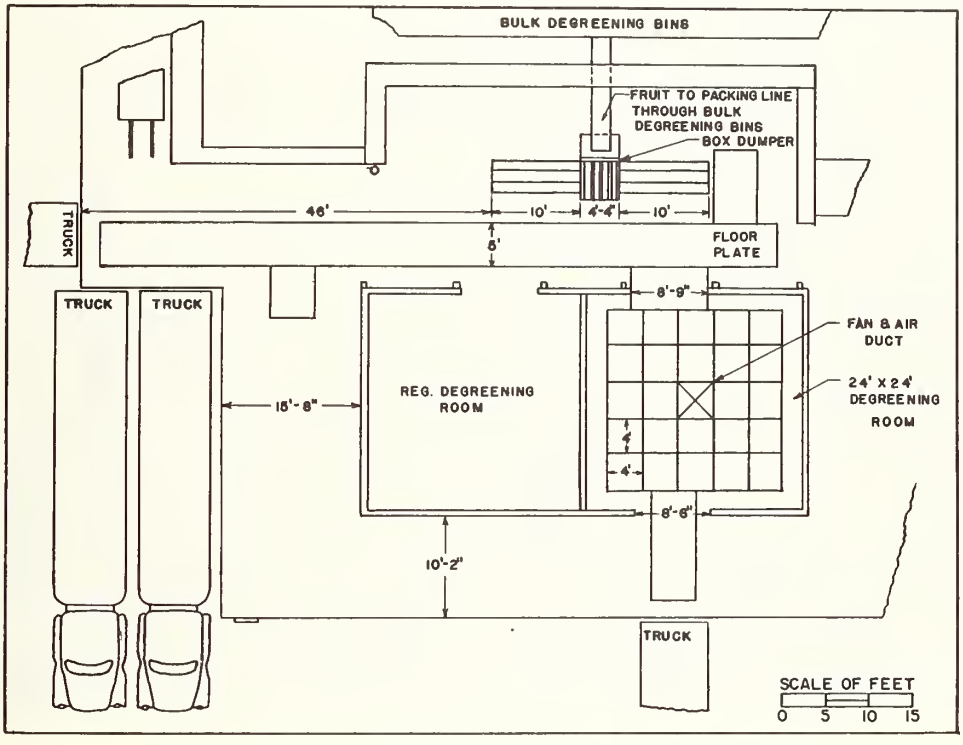

Figure 1.--Layout of packinghouse equipment and facilities used for the experimental handling of fresh oranges in pallet boxes. Field box fruit not in the experiment was degreened in the regular degreening room.

Unloading and Receiving

Unloading and receiving facilities were poor. An uneven road bed served a wooden packinghouse platform. Trucks were unloaded from the rear, using a plain steel bridgeplate between the truck and the unloading platform. This unloading proved far from satisfactory and a time allowance had to be made for this factor.

Degreening Room

The cooperator rebuilt its degreening room to a new design (2), especially modified to fit the dimensions of pallet boxes (figs. 1 and 2). This room was well located between the unloading dock and the pallet-box dumper. However, it was not possible to clear wide doorways or to use entire canvas walls such as are commonly used in the more modern Florida degreening rooms. The floors were especially strengthened with quarter-inch steel plate to accommodate the necessary handling equipment. This room held 48 pallet boxes in 24 two-high stacks, the space for one stack being taken by the air duct in the center of the room. Air circulation was downwards, through the pallet boxes, out to the walls, and back to the center fan set in a false ceiling (fig. 3).

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Figure 2.--Degreening room filled with experimental pallet boxes just before lowering the curtain to begin degreening.

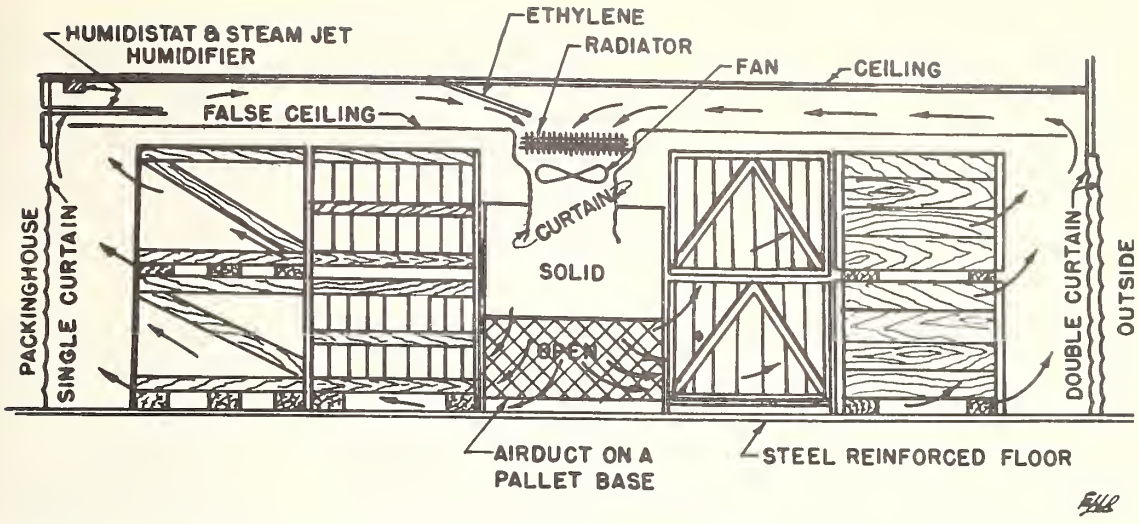

Figure 3.--Diagram of the pallet box degreening room. The excessive space left at the walls was unavoidable because the room was not designed originally for pallet boxes.

Types of Pallet Boxes

Six different types of pallet boxes were used; 20 of each type were procured. One, a commercial design, was supplied by a Florida box manufacturing firm. Another was a commercial design with some specified changes. The remaining four types were designed specifically for the purposes of this experiment and incorporated various features intended to bring out differences in convenience of handling, highway transportation, fruit damage, degreening, and box sturdiness. Details of these various boxes are given in table 1 and in figure 4. A color code was assigned to each type of box and the individual boxes were numbered. Detailed drawings of these pallet boxes are given in the appendix.

Handling Equipment

The handling equipment used most of the time was a "walkie, stacker-type," electric-powered forklift truck of 2,500 pounds capacity at 24-inch load center. Also available, as an additional unit for a short period, was an electric-powered narrow-aisle forklift truck of 2,000 pounds capacity at 24-inch load center with a "reach" mechanism permitting the forks to extend and retract 2 feet horizontally. Detailed data on this equipment are given in the appendix.

Table 1.--Dimensions and structural features of six types of 4-way entry pallet boxes studied and used during first season's operation

Box type and structural features	Dimensions						Net volume of boxes	Net capacity		Approx. weight of oranges 3/	Average weight of pallet boxes	Total weight pallet boxes and fruit	Average number of cycles boxes were used
	Outside			Inside				Field box equiva. 1/	Field box equiva. 2/				
	Length	Width	Height	Length	Width	Height							
	Inches						Cu. ft.	Boxes	Boxes	Pounds	Pounds	Pounds	Number
A Wood-inside framing, solid sides, spaced bottom, corners of 4 x 4's cut diagonally	47-1/4	47-1/4	30	45-1/2	45-1/2	24-3/4	29.65	12	10.7	960	196	1,156	11.55
B Wood-outside framing, spaced sides, spaced bottom, corners of 2 x 4's fastened with aluminum screw nails	48	48	33-3/4	45	45	28-1/2	33.4	12	12.0	1,080	258	1,338	13.1
C Iron frame, spaced sides, spaced bottom, corners of 1-1/2 x 1-1/2 x 3/16 angle iron	47	47	33	45	45	26-3/4	31.35	12	11.3	1,017	251	1,268	9.35
D Nesting box, iron frame, plywood sides, spaced bottom, corners of 1-1/2 x 1-1/2 x 3/16 angle iron 5/	top 45 btm 36	top 45 btm 36	33-1/2	top 43 btm 34-3/4	top 43 btm 34-3/4	27-1/2	24.16	9	8.7	783	202	965	1.7
E Commercial box knockdown type, spaced bottom, corners were wirebound	47	47	33	44-1/2	44-1/2	27-1/2	31.51	12	11.3	1,017	154	1,171	12.5
F Commercial box, wire-bound spaced sides and bottom, corners were wire tied	44-1/2	44-1/2	31-3/4	42	42	26-3/8	26.9	10	9.7	873	130	1,003	9.0

1/ Provided by grove foreman.
2/ Using 2.23 cubic feet per field box--legally 4,800 cubic inches (Florida Citrus Code of 1949, as revised 1951, Florida Statutes Chap. 601.86).
3/ Using 90 pounds per field box of fruit (Florida Citrus Code of 1949, as revised 1951. Florida Statutes Chap. 601.15 (3c).
4/ A cycle is the course traveled by the pallet box from the dumper, through the grove operation and back to the dumper.
5/ Not used after initial degreening trials due to difficulties in handling this type of box.

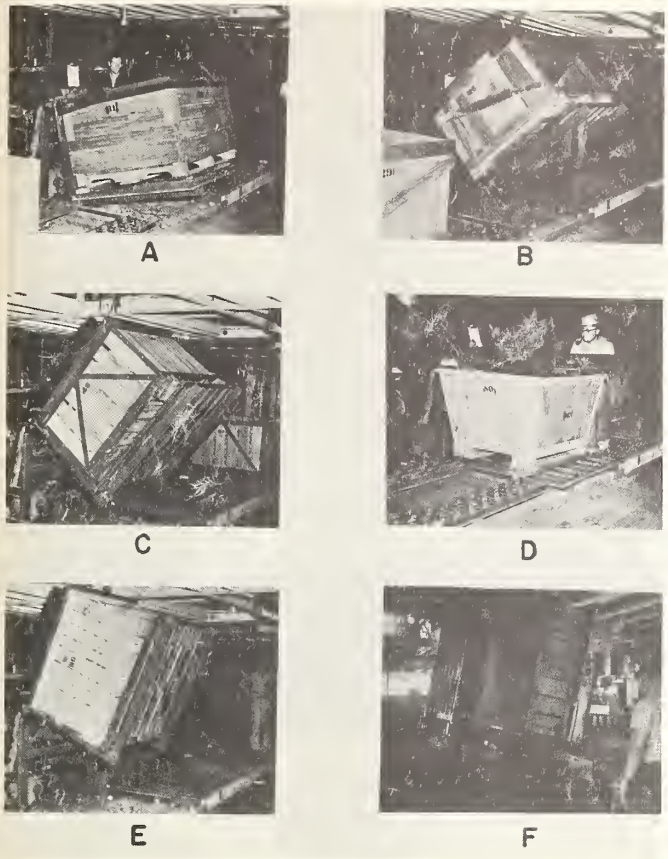

Figure 4.--The types of pallet boxes shown in various positions on the pallet-box dumper. Letters correspond to those given in table 1. Note sand pouring off flotation strips in B.

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Pallet Box Dumper

A commercial pallet-box dumper of the smallest capacity deemed practical (1,500 pounds), was purchased and installed in the commercial packinghouse (fig. 4). This dumper rotates the box approximately 120° about one upper edge by hydraulic cylinders. This is a very common type of commercial pallet box dumper but it could be improved. The dumper dumped the fruit into a bulk bin or hopper to provide an even flow of fruit to the packinghouse. The hopper had baffles of stretched cider press cloth (13).

Description of Groves

The experimental work in the groves was carried on in four blocks of orange trees, three of which (blocks A, B, and C) were in the Bel Air grove of the cooperator near Sanford, Fla. The fourth (block D) was in a grove northeast of Mount Dora, Fla., about 20 miles from the packinghouse. Details of these groves are shown in table 2. The soil is sandy, as is universal in the interior of Florida. At this north end of the so-called Ridge District, the sand is somewhat firmer and provides better footing for equipment than the very

Table 2.--Details of orange groves used in pallet box harvesting trials, 1959-60

Detail	Unit	Block A	Block B	Block C	Block D
Variety of oranges	--	Parson Brown, Hamlin, and Pineapple	Parson Brown, Hamlin, and Pineapple	Valencia	Valencia
Distance between rows	Feet	15	20	30	25
Age of trees	Years	25 to 30	25 to 30	20 to 25	12 to 14
Distance from block to loading area(s)	Feet	300	1,100	3,500	1,200 and 1,600
Distance from grove to packinghouse	Miles	2.5	2.5	2.5	20
Loading area	Feet	30 x 100	30 x 100	100 x 100	35 wide
Date of picking	--	11-15-59	11-15-59	4-17-60	4-17-60

light fine sand found at the southern end of the Ridge District. In no case was there sufficient slope to interfere with the efficient operation of the grove equipment.

Loading Areas in the Groves

The loading areas for the three blocks in the Bel Air grove were very firm, grass-covered sand and in each case were large enough to provide adequate maneuvering space for the tractors. Two grove-side loading areas were used for Block D in Mount Dora, both of which were rather inadequate, being only about 35 feet wide; the ground was not very level.

Transportation Equipment

The semitrailers used were of the standard flat-bed type used for citrus (fig. 5). Two sizes were used. One was 8 feet wide, 34-1/2 feet long, with the truck bed 52 inches high. It held 32 pallet boxes in 16 2-high stacks--8 stacks on each side of the truck bed. The other semitrailer was 8 feet wide, 30 feet long, 52 inches high, and held 28 boxes. Eight feet is the maximum legal width for such highway equipment in Florida 3/. Neither the equipment itself nor the load may project beyond this.

3/ Florida Statutes: Section 320, 41.

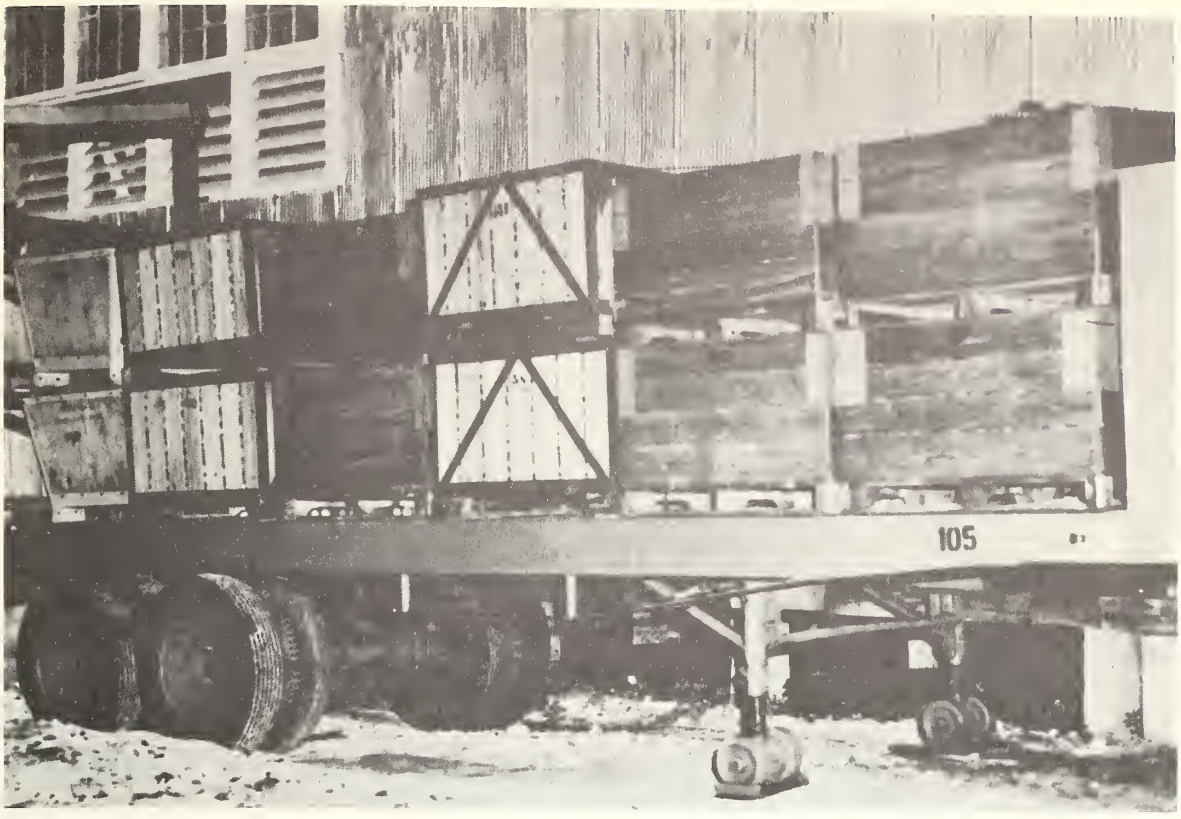

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Figure 5.--A 30-foot standard flat-bed semitrailer at the packinghouse with a load of 28 pallet boxes of various types used in the tests.

Field Equipment

Three types of tractors were compared for desirable characteristics for grove operations. Data for these three types are in appendix table 6, and requirements are in the section Results of Study, p. 18.

A device used for loading bulk fruit for cannery purposes was tried for loading pallet boxes but proved unsatisfactory for grove use without further modifications which were not carried out (fig. 6).

Fruit Receiving Area

There was no fruit-receiving area as there are at many deciduous-fruit packinghouses that use pallet boxes. Neither was there a tractor equipped with forklift attachments available at the packinghouse. Highway trucks had to back up to the platform and be unloaded by the forklift trucks used for in-plant transportation.

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Figure 6.--A device for loading bulk fruit is transferring pallet boxes from a grove truck onto a semitrailer for transportation to the packinghouse.

EXPERIMENTAL PROCEDURE

The personnel involved in this study were from offices as far apart as Gainesville, Sanford, and Lake Alfred (all in Florida) and East Lansing, Mich. For this reason various phases of the research had to be conducted separately. Moreover, the use of the very large quantities of fruit involved in the tests necessitated synchronization with normal commercial operations so that this fruit could be handled as commercial fruit.

Work Pattern

A semitrailer full of empty pallet boxes was spotted at the loading area at approximately the same time that the picking crew and tractors arrived. The boxes were either unloaded two at a time, transported into the grove four at a time, and spotted around the trees by use of a forklift-equipped tractor, or the semitrailer was unloaded all at once and the pallet boxes spotted through the grove later by the forklift-equipped tractor. In the first case, the semitrailer body was uncoupled and remained at the loading area. As the boxes were filled, the foreman or crew boss, who drove one tractor, or his

helper, who drove another, picked up the filled boxes, transported them to the loading area and loaded them two-deep onto the semitrailer. When the semitrailer was not kept at the loading area, the full boxes were lined up in the loading area and loaded onto the semitrailer when it returned.

A picking crew consisted of 11 to 14 pickers, although on one day there was a crew of 17. The crew boss operated one of the forklift-equipped tractors and was paid 2¢ per field-box equivalent picked by the whole crew and guaranteed a minimum of $12 per day. A second driver operated the other forklift tractor and was paid 1.5¢ for each field-box equivalent picked by the whole crew.

When a picker had filled one of the pallet boxes (fig. 7) he put an identifying tag with his number on it on top of the fruit in the box. The full box then was picked up by the tractor driver and moved to the truck loading area.

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Figure 7.--Picker emptying his picking bag of oranges into a pallet box (Type A).

Time Studies

The various operations such as picking up and putting down boxes, maneuvering loaded tractors through 180° (to change from front to back forks and vice versa), loading and unloading trucks, pickers filling pallet boxes, and so on, were analyzed separately, each operation being studied individually under commercial conditions. With practice, grove forklift operators should easily perform these operations in times equal to or even faster than those presented here. Times for complete operations such as loading a semitrailer are synthesized by combining these individual times with allowances for lost time, personal requirements, fatigue, and the like.

Time studies were conducted in the packinghouse in a manner similar to those in the grove, but more synthesis was necessary to provide realistic time values. This was because the poor unloading arrangements caused delays which had to be considered and adjustments made. The location of the doors in relation to the degreening room caused out-of-line travel of the forklift truck and an allowance was made for the considerable unnecessary maneuvering. Space was generally inadequate for operating powered forklift trucks. Also, the dumper was fed by manually pushing the pallet boxes along a roller conveyor; empty boxes were removed from the dumper in the same way. Every effort was made to ignore such nontypical factors, to provide time values which reflected efficient operating practices.

Degreening Studies

The degreening room was wired with thermocouples connected to a 12-point temperature recorder. Two thermocouples were adapted to form a "wet bulb-dry bulb" hygrometer and a portable hygrothermograph also was used in the room. The room was equipped with a steam jet humidifier controlled by a "humidistat." This apparatus insured even temperature in the room and made possible regulation of the humidity within the room to rather narrower limits than is usually attempted. A continuous check on fruit color could not be made, but samples were taken from the various types of boxes within the room and from fruit degreened in field boxes in the same room. Color comparisons were made by methods described in the literature (2, 5, and 18) to determine any differences between degreening in field boxes and pallet boxes and among the various types of pallet boxes.

Damage and Decay Studies

The standard procedure for determining whether the fruit had suffered damage during handling was by taking a sample, usually of 100 fruit, bringing it to the Citrus Experiment Station, and, if the fruit had not already been washed and waxed, adding the treatments necessary in commercial practice for shipment. 4/ Thus, unwashed samples taken from any stage between the tree

4/ The company at which the tests were run uses a commercial decay control treatment (7), on all fruit shipped. This treatment was deliberately omitted from experimental samples which thus were not truly typical of normal commercial shipments from this plant.

and the washer were washed and waxed at the Citrus Experiment Station. Other samples taken part way down the line in the packinghouse received only those treatments which they had not already received. These samples were then packed in closed fiberboard cartons such as are normally used for shipping fruit.

The boxes of fruit were then put through a simulated shipping test as described in earlier publications (3, 4). They were held at 60° F. to simulate refrigerated transit conditions for 6 days, after which they were held at 70° F. for 4 days to simulate non-refrigerated conditions in warehouses and retail stores. After this period (i.e., 10 days from packing) they were considered to have reached a time equivalent to retail sale. The samples were then examined, the fruit counted, decayed fruit removed and the type of decay recorded. Peel injuries were recorded, but the affected fruit was not removed. After examination, the fruit was placed in open wooden containers to approximate fruit-bowl conditions in the customer's home. They were examined again after an additional 7 days at 70° F., on the assumption that the average customer usually shops for citrus fruit about once a week.

This procedure was immensely complicated by the fact that fruit arriving at the packinghouse did not follow a single procedure. Some was washed and stored in bulk bins; sometimes the fruit went straight from the dumper into the washer and from there into the packinghouse. A fungicidal process (7) was used in a washer.

A further complication was the large number of types of pallet boxes. A complete sampling pattern would be multiplied by the number of types of boxes used if every possible condition were to be tested. Added to the multiplicity of types of treatment on entering the house, this would have made complete sampling impossible, if only on the score of the enormous amount of fruit that would have to be stored and handled. For this reason, sampling was limited to the conditions in which decay seemed most likely to be stimulated, or else to follow through particular operations. Unfortunately, such a sampling pattern is not suitable for statistical analyses.

Cost Analysis

The cost analysis was limited to determining the relative costs for this method and the conventional field-box method. Therefore, costs were estimated for these two methods covering the handling operations from grove to dumping fruit onto the packinghouse equipment. These estimates were made with heavy reliance on earlier research on fruit handling (13, 16) in which data were presented on the physical inputs of labor and equipment required as well as costs. These inputs were combined with current (1960) wages and prices to compute the costs for the field-box method. For the pallet-box method, the physical labor and equipment inputs were determined by studies during the 1959-60 season. The results of these studies constitute other sections of this report.

The method used to determine costs was to establish the labor and equipment requirements for weekly operating rates of 5,000, 10,000, 15,000 and 20,000 field-box equivalents per week. From these data, annual fixed costs and variable costs per box were computed, and, in turn, used to compute total costs at a series of annual volume levels (100,000 to 600,000 boxes).

RESULTS OF STUDY

Grove Studies

Equipment

Differences in performance of the various types of equipment were sufficient to make possible a set of specifications needed for forklift-equipped tractors for this type of usage. The following requirements were considered desirable or necessary:

(1) The front tires should be at least 9.00 x 16 and the rear tires 14.00 x 24 with a knob tread rather than a bar tread. Such tires provided the necessary load flotation for the sandy conditions encountered in these trials.

(2) Power-steering is definitely required in grove handling.

(3) A "shuttle" type transmission is recommended because of the many forward-reverse movements encountered.

(4) Lift masts should be provided on both front and rear of the tractor with a minimum capacity of 3,000 pounds lifting to a height of at least 60 inches.

(5) Rear tires should contain liquid ballast at low pressure.

(6) A "side-shifter" is desirable on the rear lift mast for loading highway trucks. Although the front end is more maneuverable than the rear because of steering action, the industry cooperator felt that a side-shifter would be desirable on the front mast, also.

Picker-Crew Reaction

The workers picked on the average 10.1 field-box equivalents per hour, which compares very favorably with their picking rate with field boxes. All pickers were interviewed. A few of them felt that they picked more fruit with pallet boxes because they did not have to pause to level field boxes, arrange them for the loaders, and move them from tree to tree. Another favorable comment was that accounting was easier in that the picker had only 1 ticket for each pallet box instead of perhaps 10 tickets for the equivalent amount of fruit in field boxes. Oddly, none of them commented on the longer walks necessary to fill a large container than to fill the numerous small containers. The only objection offered was the necessity for lifting the picking bag over the edge of the pallet box, especially the ones that were 32 inches or more high. All pickers liked the orange-coded box type (Type A, wood inside framing, 30 inches high) because of its lower and smoother sides. Of the 16 pickers interviewed, 8 liked the pallet boxes better than the field boxes, 5 were indifferent and 3 liked the field boxes (1 because of the lifting of the picking bag over the side of the pallet box; and the other 2 said they were accustomed to field boxes and had used them all their lives). The crew boss

said he definitely preferred the pallet boxes; thus it was easier for him to keep count of the fruit picked and, being on the tractor, he could move about quickly and do a better job of supervising the crew. This is a comment that was common among foremen and crew bosses on all types of bulk handling operations in which the supervisor rides a tractor instead of walking around the grove (11, 12). The loader who drove the other tractor also said he definitely preferred the pallet boxes, since he did not have to do heavy physical work and could work more effectively and make more money as a result.

Time Studies

Time requirements were obtained for performing the essential operations in grove handling of pallet boxes. The times are averages on data obtained on actual operations under commercial conditions. With practice, grove forklift operators should easily perform the operations in times equal to or faster than those presented here.

Inter-Area Travel.--The time values given here are the number of seconds required per foot of travel between the loading area and the picking area, or vice versa, of the tractor forklift traveling either empty or when carrying full or empty boxes (fig. 8). This element begins when the tractor forklift starts the designated kind of travel and ends when it stops such travel. These times were developed from total elapsed trip times (including straight runs and turns) divided by the total distance traveled. Travel times are:

Tractor empty -- 0.100 second per foot (6.8 mph)

Four empty pallet boxes carried -- 0.152 second per foot (4.47 mph)

Four full pallet boxes -- 0.176 second per foot (3.86 mph)

Two pallet boxes, either empty or full, on the front forks slow the operation because the driver has to peer around them. Carrying full, rather than empty, pallet boxes slows the operation because of the resultant, slow acceleration (four full pallet boxes weigh approximately 6,000 pounds).

Inter-Tree Travel.--This is the time in seconds per foot for travel within the picking area, including straight runs, turns, and the like (fig. 9). This element begins when the tractor forklift starts the designated kind of travel and ends when it stops such travel. Times are:

One to three empty boxes -- 0.251 second per foot (2.71 mph)

One to three full pallet boxes -- 0.329 second per foot (2.07 mph)

Four full pallet boxes -- 0.292 second per foot (2.3 mph)

The small differences are probably due more to the fact that the driver traveling entirely with empties or entirely with full pallet boxes knows where he is going. Under other circumstances he is looking for full pallet boxes to pick up or place where he can spot empty ones. A separate study of the effect of empty pallet boxes on the front lift obscuring the driver's vision showed that the presence of such boxes slowed the rate of travel from 2.51 mph to 2.22 mph.

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Figure 8.--Transporting four full pallet boxes (Type D boxes on front forks, Type E on rear forks), weighing approximately 6,000 pounds, from picking area to loading area by forklift-equipped tractor.

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Figure 9.--Moving a full pallet box on the rear fork of a forklift-equipped tractor. (The picker in the background is using typical equipment--a "pole" ladder supplied by his employer and a large "jumbo" 100-pound-capacity picking bag that belongs to him.)

Approach for Pickup.--This is the time in seconds from the moment when the tractor forklift is approximately its own length (12 feet) from the pickup point to the moment when the pickup begins. Average approach time for ground level pickups was 27.6 seconds with no consistent difference attributable to direction of travel, extent of load, and the like. Approach times for pickup at truck-bed level averaged 28.8 seconds, again with no differences attributable to the above factors.

Pickups.--This is the time in seconds from the moment the forks enter the pallet to the moment when the pallet box clears its original position (figs. 10 and 11). Pickup times averaged:

Front forks, ground level.....15.2 seconds

Front forks, second-tier level 5/.....19.2 seconds

Front forks, truck-bed level 6/.....13.1 seconds

Rear forks, ground level.....26.8 seconds

Rear forks, second-tier level 7/.....27.5 seconds

Rear forks, truck-bed level 8/.....10.4 seconds

5/ When destacking empties.
6/ When unloading empties.
7/ When destacking empties.
8/ When unloading empties.

Pickup at truck-bed level was consistently hampered by interlocking of the pallet boxes; this was partially attributable to the varied types of boxes carried in a single load. The need for smooth-sided boxes was apparent. The very good times obtained when using the rear forks at truck-bed level are due to the fact that the rear forks are at eye level and equipped with a side shifter. The number of boxes picked up, whether the boxes were full or empty, or the number of boxes on the other end of the tractor did not materially affect the pickup times.

Crediting Pickers.--In this operation the driver dismounted from the tractor, picked up the picker's ticket, and returned to his seat on the tractor, taking an average of 15 seconds.

Approach for Release.--This is the time in seconds which starts when the tractor forklift is approximately its own length (12 feet) from the point where release is to be made and ends when the pallet box reaches the release position. Average times were:

Ground level, front forks.....18 seconds

Ground level, rear forks.....17.1 seconds

Second-tier level, front forks.....19.7 seconds

Second-tier level, rear forks.....16.4 seconds

BN-14426-X

Figure 10.--Picking up a full pallet box (Type E) with the front forks of the tractor.

BN-14427-X

Figure 11.--Placing a second pallet box (Type D) into a two-high stack preparatory to picking up both pallet boxes.

Average approach time for releases at various levels was about 18 seconds. At truck-bed level (fig. 12) the direction of approach did not affect the approach time and took 27.5 seconds. This figure is significantly higher than the average because the approach for truck-bed release must be exact if the pallet boxes are to be stacked properly on the truck. When a 40-inch pallet box is used, there is no leeway if the width of the truck and load is not to exceed the legal maximum of 8 feet.

BN-14428-X

Figure 12.--Two full pallet boxes (Type C) being positioned on the semitrailer using the front forks of the tractor at the grove-side loading area. Having several types of pallet boxes in a single load complicated the loading. The worker on the truck guided the tractor driver because obstructions on the exterior of some of these pallet boxes made this task difficult.

Release.--This is the time in seconds which starts when the pallet box enters the space in which it is to be released and ends when the forks clear the pallet. Average release times for both full and empty boxes were:

Ground level (either one or two empty boxes).....8.6 seconds

Second-tier level (one full box only), front forks...32.6 seconds

Second-tier level (one full box only), rear forks....32 seconds

Truck-bed level (two full boxes), front forks.....29.8 seconds

Truck-bed level (two full boxes), rear forks.....32 seconds

180-Degree Turns.--A 180-degree turn is necessary to change from using front to back forks and vice versa. This operation averaged 25.2 seconds.

Production Studies

In addition to the analyses of individual operations through time study, time logs were kept on actual operations of from 2 to 6 hours duration. These data have been analyzed to give estimates of picking rates, time spent in supervision, resting, and the like.

Picking Rates.--On the average, a picker filled a pallet box (10 field-box equivalents) in 59.4 minutes. While picking continually, a picker was working at an average rate of 10.1 field boxes of oranges harvested per hour. In all, 6,000 field-box equivalents of oranges were harvested during the period that these observations were made. The overall average picking rate was 8.8 field-box equivalents per hour per picker, or 12.8 percent slower than the rate of 10.1 field-box equivalents for actual picking time. This loss of 12.8 percent is due to the time spent by the picker in resting, smoking, eating, getting his tree assignments, etc. No separation of these individual factors was made.

Crew Boss.--It was estimated that the crew boss would need to spend only 10 percent of his time to do a good job of supervising the crew, because in operating the tractor forklift he sees every full box, moves about the grove constantly, and visits all his pickers in turn. In actual time trials, the crew boss spent 11 percent of his time in supervision, 74 percent in handling fruit and the remaining 15 percent in resting and waiting for something to do. It is considered that this last figure need be no more than 5 percent of his time, once an efficient operation is established.

Loader Operator.--When a second grove tractor forklift is used, the driver should, in theory, be able to spend 95 percent of his time in productive work, the other 5 being used to rest, and the like. In these trials, the loader actually used only 65 percent of his time in productive work; the rest of the time he was waiting for something to do. This illustrates a point that has been apparent in other harvesting studies (11, 12). If equipment is to be multiplied (as when increasing from one to two tractor forklifts) efficient use of such equipment and the operators can be obtained only if the size of the picking crew is adjusted accordingly. These crews were far too small for optimum utilization of these two pieces of equipment and their drivers.

Packinghouse Operations

Labor and Equipment Inputs

The overall limitation on this operation was set by the performance of the forklift equipment that was available and the experimental conditions affecting its use. Base time data for this equipment are given in the appendix, which presents figures for these trucks operated under efficient conditions. In actual practice, such conditions prevailed only for very short periods, or very short distances, and allowances had to be made for the typical conditions under which the actual operation was carried out. Table 3 shows preliminary labor

and equipment requirements for handling 1,000 field-box equivalents of fruit in pallet boxes under conditions permitting effective use of the equipment. As might be expected, the time was always shorter for the various operations when using a conventional type forklift truck on which the operator rides, than with the "walkie" type with which the operator walks behind the machine. The latter type is, however, very maneuverable.

Table 3.--Labor and equipment requirements per 1,000 field-box equivalents developed from experimental handling of oranges in pallet boxes at the packinghouse (preliminary) 1/

Activity	Dumper	Lift trucks	
		Walkie-type	Conventional type 2/
	Man-hours	Man-hours	Man-hours 3/
Unload 2-high stacks of filled boxes from semitrailer and place in degreening room; effective travel distance of 50 feet one way	--	1.13	0.87
Remove 2-high stacks of filled boxes from degreening room, deliver to dumper and destack; effective travel distance of 70 feet one way	--	1.56	1.26
Dump fruit from pallet boxes	2.04	--	--
Stack empty boxes 2-high at dumper and load onto semi-trailer; effective travel distance of 70 feet one way	--	1.54	1.34

1/ Based upon a pallet box of 10-field-box capacity and a degreening room with full-width canvas curtains which are rolled up for forklift truck access. Fatigue allowance and personal allowance of 5 percent each are included.

2/ Rider-type.

3/ Use was made of standard time data for conventional forklift truck developed jointly by the Yale and Towne Co., and the Wharton School, University of Pennsylvania.

The pallet-box dumper operated at a speed sufficient to feed the packing line at a rate of 490 field-box equivalents per hour. This could probably be improved by having powered conveyors to feed the boxes into the dumper and to remove the empty boxes. Use of such powered conveyors would also reduce from two to one the number of workers needed to operate this dumper.

At a dumping rate of 490 field-box equivalents per hour, 2 conventional (rider-type) forklift trucks handling 2 boxes per load (20 field-box equivalents) would be needed: 1 to bring filled boxes from a degreening room or semitrailer to the dumper and 1 to take away empty boxes and load them on to a semitrailer. Two such conventional forklift trucks could travel to points about 235 feet (1 way) from the dumper and still keep pace with it. With walkie-type forklift trucks, it would be possible to service points only up to about 125 feet from the dumper and keep pace with it. Work done by the forklift trucks included destacking the filled boxes onto the dumper conveyor and restacking empty boxes two-high and taking them away from the dumper conveyor. A comparison of the preliminary labor requirements for the pallet-box system with those of the conventional field-box system is shown in table 3.

Costs

The average cost per 1 3/5-bushel equivalent for handling fruit in field and pallet boxes is presented in table 4. These data show that the pallet-box method has a clear advantage over the field-box method at all seasonal volumes and at all weekly operating rates. In the one-tractor situation the savings in costs for pallet-box handling would be about 7 cents a box for most volume situations. For the operating rate of 10,000 boxes per week the difference is 6 cents per box. The addition of a second tractor increased the costs for the pallet-box method. A definite advantage for the pallet-box method still existed, however, because the increase in costs amounts to about 2 cents per box. Therefore, the cost advantage for the two-tractor situation is about 4 or 5 cents, depending upon the operating rate and season volume. These costs relationships are presented graphically in figure 13 for the operating rate of 15,000 boxes per week.

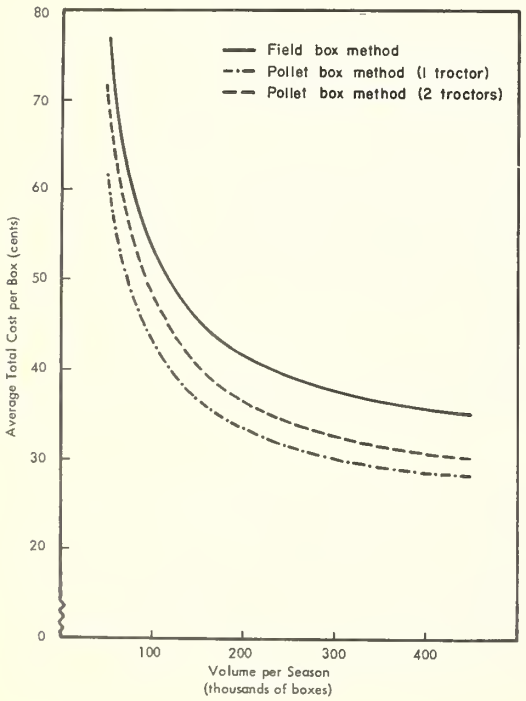


Figure 13.--Costs for picking, hauling, receiving, and dumping oranges in field and pallet boxes at the rate of 15,000 1 3/5-bushel-equivalent boxes per week.

Table 4.--Comparison of total labor and equipment costs for handling oranges by field-box and pallet-box methods from the tree to the packing line

Method	Volume per week	Average cost per box for total seasonal volume of --					
		100,000 boxes	200,000 boxes	300,000 boxes	400,000 boxes	500,000 boxes	600,000 boxes
	Boxes	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Field box...	5,000	0.4085	1/	--	--	--	--
	10,000	.4686	0.3857	0.3580	2/	--	--
	15,000	.5367	.4177	.3781	0.3583	3/	--
	20,000	.5997	.4483	.3978	.3726	0.3574	0.3473
Pallet box (1 tractor)..	5,000	.3293	1/	--	--	--	--
	10,000	.4009	.3230	.2970	2/	--	--
	15,000	.4286	.3345	.3031	.2874	3/	--
	20,000	.4736	.3564	.3173	.2978	.2861	.2782
Pallet box (2 tractors):	5,000	.3538	1/	--	--	--	--
	10,000	.4193	.3375	.3102	2/	--	--
	15,000	.4811	.3660	.3276	.3084	3/	--
	20,000	.5544	.4020	.3512	.3258	.3106	.3005

1/ Maximum volume that can be handled per season when operating at this weekly volume is less than 200,000 boxes.

2/ Maximum volume that can be handled per season when operating at this weekly volume is less than 400,000 boxes.

3/ Maximum volume that can be handled per season when operating at this weekly volume is less than 500,000 boxes.

Fixed and direct costs for labor and equipment are given in the appendix (tables 7 through 13). Annual fixed costs for handling fruit in pallet boxes with one tractor are lower at most volume levels than for the field-box method. At an operating rate of 20,000 boxes per week, this difference is about $7,000. Some of the pallet-box handling equipment is more costly than the comparable units for field-box handling. For example, the annual costs for the grove tractor are usually higher than the cost for goat or flat-bed trucks used to handle field boxes. The cost for highway hauling equipment is equal because the same amount of fruit is handled on the semitrailer truck with each method. The dumping installation costs also are about equal. The empty field-box conveyor, in a sense, corresponds to the forklift trucks which handle both filled and empty pallet boxes. The annual fixed costs for forklift trucks are higher than that for the empty box conveyor. The greatest disparity is in fixed costs for boxes. The annual fixed cost for field boxes is estimated to be 96¢ per unit. This compares with an annual fixed cost for pallet boxes of $3. However, for every 1 pallet box in use, 10 field boxes are required. Fixed costs for the two-tractor situation are quite close to those of the field-box method. The addition of one grove tractor per crew about offsets the fixed cost saving on boxes.

Direct costs are expressed in dollars per 1,000 of 1 3/5-bushel units. The field-box method was more costly in all cases. This difference is about $60 per 1,000 boxes, assuming one tractor for pallet boxes, and about $50 for two. This means that the extra tractor resulted in an increase in direct operating costs of $10 per hour.

Decay and Damage Studies

The first decay study was carried out with early oranges picked November 16 and packed on November 20, 1959 (appendix, table 14). 9/ This study was aimed only at determining whether there was any significant increase in damage when harvesting in pallet boxes rather than field boxes. Average losses from decay were:

Sample	Average loss, all causes	
	At "retail sale"	"1 week later"
	Percent	Percent
1. Control	15.8	21.1
2. Pallet boxes before degreening	18.8	38.3
3. Pallet boxes after degreening	14.4	31.2

Unfortunately the control (sample No. 1) was, due to a misunderstanding, brought to the packinghouse in a mesh bag rather than in a standard field box. Up to the 10-day ("retail sale") examination there was virtually no difference in total decay between the various samples except for sample No. 2, which received an extra handling since it was removed from a pallet box and put into a field box on arrival at the packinghouse and prior to degreening. This sample was taken from the bottom of the pallet box and it is possible that, in digging this deeply into the box, some damage was done to the fruit. There was no indication here that harvesting, hauling, and degreening in pallet boxes was injurious to these early oranges.

The second decay study (appendix, table 15) was also made on early oranges of mixed varieties 10/: Hamlin, Parson Brown, Homosassa, and Seedlings. Check samples were placed in field boxes but were accidentally dumped by the packinghouse labor force. After arrival at the packinghouse, a new "control" sample was made up by taking oranges from the tops of the pallet boxes where the fruit had not been in contact with the sides. Two such control lots, each of 100 fruit, were used. In addition, two types of pallet boxes (type A and type B) were compared. Samples were taken from two such boxes as the oranges poured from the dumper, and again as they left the bulk receiving bin (fig. 1).

9/ All fruit handled commercially through this packinghouse receives the fungicidal treatment (7, 8). This was omitted on all experimental samples. Because of this, the decay losses recorded here are not representative of normal shipments from this packinghouse.

10/ In many of the older citrus groves, varietal identification is, at best, tentative, and there is considerable overlapping between early and mid-season varieties.

The appendix, table 15, also includes data on two samples taken from fruit picked in field boxes from another grove that was being put into bulk receiving bins without prior degreening. This fruit came from a different grove, was picked by a different crew, and can be taken as being typical of fruit coming into the house by standard methods but not strictly comparable with the crop picked in pallet boxes. Average losses from decay (excluding the dubious control) were:

Sample	Average loss, all causes	
	At "retail sale"	"1 week later"
	Percent	Percent
Pallet boxes:		
Before dumping	0.0	3.3
After dumping	5.6	10.4
After moving through bulk receiving bins	7.6	19.2
Field boxes (different crop):		
Before dumping	0.0	8.6
After dumping and conveying upstairs	3.0	5.2

The extremely low incidence of decay in the samples taken before dumping indicates that the fruit was basically sound. It is hard to make any other definite observations, since there are no consistent differences between decay in fruit from the two types of pallet boxes or between fruit sampled at dumping or after it has been through the bulk receiving bin. There is undoubtedly some evidence of damage due to handling, but no more so than is normally encountered in field boxes. Table 15, appendix, shows that the sharp increase in average decay at the final examination is due to a major increase in stem-end rot in one sample (No. A-4). This is unexplained. It cannot be attributed to the type of pallet box or the same effect would be seen in sample No. A-3; nor can it be due to passage through the bulk bin or the same effect would be seen in sample No. A-6. Stem-end rot is an endemic organism and infection in the groves is a prime requisite for this type of decay. Hence, the difference may not be due to the handling method at all.

Two decay checks were carried out, using midseason fruit (appendix, tables 16 and 17). On January 26 the five types of pallet boxes were sampled before and after dumping. Average losses from decay were:

Samples	Average loss, all causes	
	At "retail sale"	"1 week later"
	Percent	Percent
Before dumping	36.9	76.1
After dumping	41.1	79.5

The increased loss due to dumping is very moderate, may not be significant, and would almost certainly be obviated by the fungicidal treatment (7, 8) that this fruit would have received prior to commercial (rather than experimental) shipment.

This test was repeated (appendix, table 18) with a few field boxes included as a check. Contrary to instruction, the driver brought these in as a single layer rather than in a stack. This could reduce damage substantially by comparison with the normal four-high stack. Average losses from decay were:

Samples	Average loss, all causes	
	At "retail sale"	"1 week later"
	Percent	Percent
Pallet boxes before dumping	39.9	69.3
Pallet boxes after dumping	32.7	69.2
Field boxes	24.2	57.3

There is obviously no significant difference between "before" and "after" dumping. The difference between decay of fruit hauled in pallet boxes and in field boxes is probably significant, especially as the increased loss is almost entirely due to Penicillium, which is typically a symptom of mechanical injury, particularly in the winter months.

Five types of pallet boxes were used in the studies reported in appendix, tables 16, 17, and 18. All were sampled individually before dumping and provide some basis for comparison between boxes. Differences were not consistent from test to test. The average overall losses from decay were:

Pallet box type	Average loss, all causes	
	At "retail sale"	"1 week later"
	Percent	Percent
A	36.8	72.1
B	50.2	77.2
C	42.6	72.1
E	41.5	73.1
F	34.0	71.3

About all that can be said from this is that decay tended to be least in the F and A type pallet boxes and most in type B.

On April 20, 1960, when Valencia oranges were being harvested, samples were taken throughout the entire operation, although only samples connected with harvesting procedure are quoted here (appendix, table 19). Due to the large size of the fruit, half-box samples averaged only about 60 fruit each.

A random sample was picked by research workers directly from the tree into cartons. This was compared with a sample taken from the tops of the pallet boxes after loading on the highway truck, thus representing commercial picking and in-grove transportation. For this test, the simulated shipping test was extended to include an "arrival" examination equivalent to a PACA examination 11/. Subsequent losses from decay were as follows:

Sample	Average loss, all causes		
	At "arrival"	At "retail sale"	"1 week later"
	Percent	Percent	Percent
Special picking	0	0	7.7
Commercial picking	0	1.6	6.5

Surprisingly there is no evidence of damage by the pickers.

Further samples from this same picking handled in two types of pallet boxes (A and E) were taken from the following points: Various depths in the boxes on arrival at the packinghouse, after dumping, and after the fruit passed through the bulk bins. Subsequent losses from decay were:

Sample	Average loss, all causes		
	At "arrival"	At "retail sale"	"1 week later"
	Percent	Percent	Percent
On truck	1.9	13.4	17.3
After dumping	0	5.3	19.3
After bulk bins	2.8	7.2	14.5

There is evidence of increased damage due to the 20-mile haul from the grove, but not due to handling from the highway truck to the packinghouse lines. These losses are comparable to losses for field boxes and bulk handling of Valencia oranges in this same packinghouse as published previously (13).

Pack-Out

The value of a crop as fresh fruit is sharply related to the proportion that can be packed as fresh fruit (1). Green color is a grade-lowering factor 12/ and failure to degreen adequately lowers profits (5) and could nullify financial gains. At the time of writing, one check of pack-out had been made

11/ Perishable Agricultural Commodities Act, 1958. Public Law No. 325. 71st Congress, S. 108. Laws Relating to Agriculture, pp. 74-81.

12/ U. S. Standards for Florida Oranges and Tangelos. 20 F.R. 7205 10/14/55. Production and Marketing Administration. U. S. D. A. Washington, D. C.

with early (Hamlin) oranges on November 17, 1960. A crop was divided between field boxes and pallet boxes and both were degreened in the same room. The two lots were run separately and the pack-out (in-grade, or packed, boxes per 100 box-equivalents delivered to the packinghouse) recorded. Pack-out was low due to a bad melanose infestation. Results, expressed as 90-pound box-equivalents, were:

Grove container	Delivered to packinghouse	In-grade or packed fruit	Pack-out
	Box-equivalents	Boxes	Percent
Field boxes	492	221.5	45
Pallet boxes	236	133	56.5

Although it is by no means certain that this difference is significant, it is at least in the right direction.

Samples of packed boxes were taken for a simulated shipping test. Decay at the 17-day examination was almost identical in those harvested in pallet boxes (42 percent loss) and those harvested in field boxes (43.7 percent loss).

DISCUSSION OF RESULTS

Grove

This first year's study indicated that it is physically possible to harvest oranges in pallet boxes from groves on sandy soil. Extremely poor groves (for example, ridged beds in the Indian River district, steep rolling hillocks as in some parts of Highlands County, or old closely grown, non-hedged groves) were not included. Enough experience was obtained to formulate tentative specifications for a grove forklift tractor as described above.

The time elements and delay times obtained were used to calculate the curve in figure 14. The data show that one tractor can service 14 to 15 pickers working 1,000 feet from the roadside. As interarea travel extends to 2,000 feet the number of pickers that can be serviced drops to 11. Conversely, a second tractor can be used to full efficiency only under conditions such as a 20-man crew working at over 2,000 feet from the roadside loading station.

Pallet Boxes

Considerable experience was obtained with regard to types of pallet boxes. The first lesson is that "flotation strips," or lower-deck boards, under the pallet pick up several pounds of sand, which then spills from the upper pallet into the lower pallet box in each tier. The use of 4" x 4" stringers is more practical. These should be notched for 4-way entry.

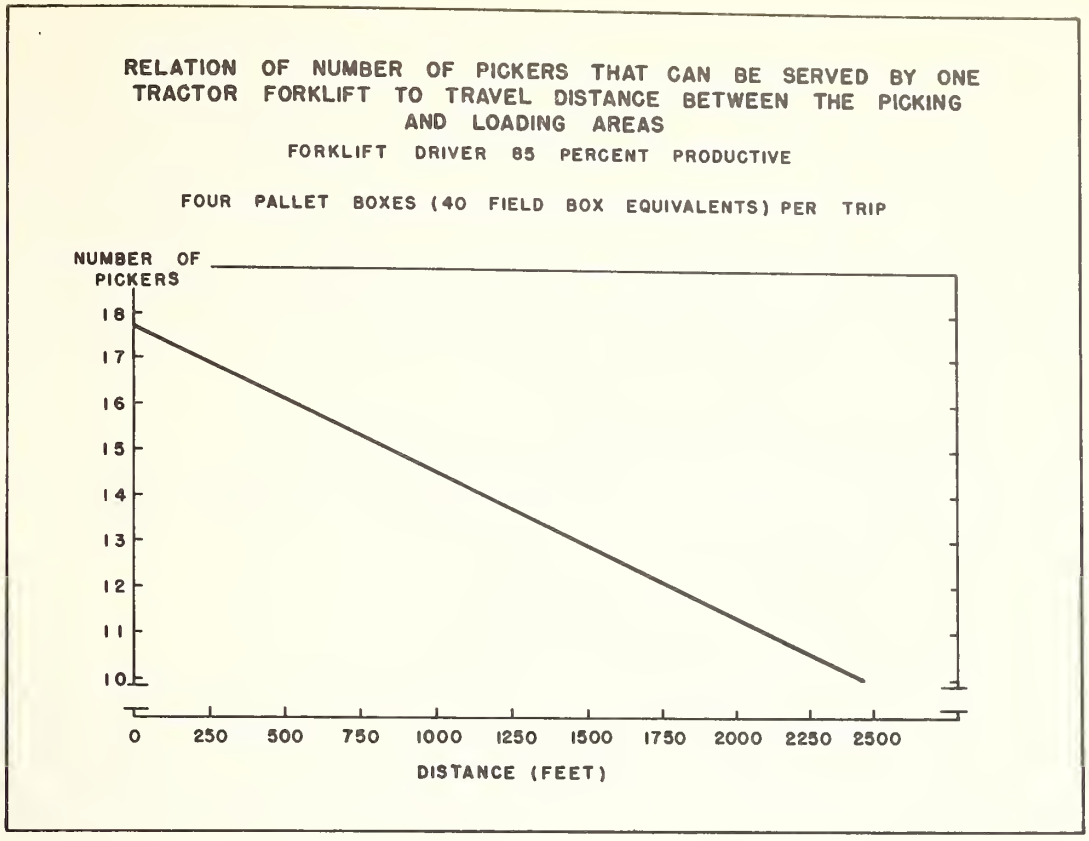


Figure 14

The bases of pallet boxes should be less than 48" x 48", because 8 feet is the maximum legal width for truck loading 13/; some latitude is essential to stay within the legal limit. Pickers experienced some difficulty in emptying the heavy picking bags into pallet boxes that were over 30 inches high. There was little advantage in the use of a nesting-type box and there were severe disadvantages in handling any box of irregular shape. Projecting bolts and iron framing were particularly bad.

Evaluation of pallet-box durability was aided by reference to a report from the U. S. Forest Products Laboratory (10) which, unfortunately, did not include wirebound pallet boxes, although commercial "knockdown" pallet boxes were included and performed well. Southern pine did not hold nails well. Hardwood was more satisfactory and allowed for designs that resulted in a lighter box. Wires on wirebound boxes tended to stretch and to break about 1 inch from the corners. This might be corrected by use of more or stronger wire.

Pallet boxes should be held securely when being transported two-high over rough terrain. This can be achieved by a hold-down device on the tractor, or by a stacking lock on the boxes, or by notching ends of the stringers so that they lock into the top of the pallet box below. The third method seems the simplest solution.

13/ See footnote 3/ p. 11.

Some pallet boxes were treated with a commercial wood preservative containing 3-percent copper naphthenate and 2-percent pentachlorophenol. As an additional precaution, a number of field boxes were also treated with this preservative and tests done with them to determine the effect of the preservative upon the fruit. The day after these boxes were treated they were filled with oranges, taken for a 20-mile truck ride, and then left in the boxes for 3 days. This resulted in very severe burns wherever the fruit touched the boxes. The test was repeated periodically with these boxes, which were stored on the roof of the building for weathering between tests. At 11 weeks after treating, the fruit no longer suffered any burns on contact with the boxes. It has been suggested to the manufacturer that this compound be sold with a label warning that the boxes should be weathered for 3 months before being used for fruit.

In the course of a single season, no beneficial effects of the box preservative could be observed as there was no change in the wood parts of the boxes to make judgment possible.

Receiving

Using in-plant forklift trucks to transport pallet boxes from semitrailer trucks into the packinghouse across a bridge plate is not satisfactory without proper dock arrangements and safety practices. A ground level unloading area, or apron, for forklift trucks is greatly preferred when other facilities are adaptable. This is the normal system in apple districts that use pallet boxes, and has been introduced very successfully into one Florida citrus packinghouse that uses field boxes.

Fruit Studies

Biological findings must be regarded as no more than tentative when based on a single season. However, evidence indicates that, with judicious pallet box handling, damage to fruit certainly need be no more than in presently used field-box handling and may be less. In particular, it should be noted that oranges could be dumped from pallet boxes without significant damage. There is no evidence indicating that fruit damage can be expected to be less than in good bulk handling of oranges. Efficient degreening appears to be no problem at all. The principles used worked so well that it should be possible to design larger pallet-box degreening rooms, using high stacking as is common in deciduous-fruit cold storages.

Dumping

The use of a multiplicity of box types greatly hampered efficient dumping. In a commercial plant, pallet-box design must be standardized, at least to the extent of having common external dimensions so that the dumper can accommodate all types of pallet boxes. The dumper used in these tests employed electric power and a hydraulic system to lift more than a 1,500-pound gross weight at a mechanical disadvantage, requiring the use of a 2-hp. motor. The manufacturer has since modified this dumper to enable it to use a 1-hp. motor to better advantage.

Costs

The final determinant of the use of any new handling system is whether the system is profitable for individual firms. Data in table 4 show that under most volume situations experienced by packing firms, the pallet-box method has a distinct cost advantage for the costs included in the analysis. It is not possible, of course, to include all costs because some factors which affect costs are not measurable. Examples of these factors are the effect of the system upon fruit quality and the kind of management problems which arise when using the new system. The quality factor is appraised in other sections of this report.

Attention has been given to the number of tractors required to service a picking crew, which depends upon the distance between the picking and loading areas. It was shown that a considerable difference existed between the one- and two-tractor situations. The anticipated saving for any given firm would depend, therefore, upon the picking-loading layout.

Annual fixed costs presented in this report have been based on 100-percent use of the equipment in the handling operations studied. However, some equipment can readily be used in other operations in the non-harvest period. Specifically, grove tractors might perhaps be used 30 to 40 percent of the time in non-harvesting operations during the period May 15 to October 15. Thus, the costs presented in this study tend to err on the high side. Individual operators would have to determine for themselves the usefulness in non-harvest operations of the equipment used in each method.

Another consideration for firms appraising the pallet-box handling system is the investment in new and different equipment. Details of equipment costs are presented in the appendix (table 7). A satisfactory grove tractor (including torque converter, shuttle-type transmission, and power-steering) can be purchased for about $5,600. A heavy-duty pallet box dumping installation could be acquired for about $5,000. Forklift trucks, suitable for handling pallet boxes of citrus fruit at the packinghouse, cost $4,000 to $5,000. The pallet boxes cost $10 to $15 each, but could cost considerably more, depending upon construction features and materials used. Very satisfactory pallet boxes are available at costs which are substantially lower per field-box equivalent of capacity than the cost of conventional field boxes.

Comparison With Full Bulk-Handling System

This report has dealt with a comparison between various aspects of handling in pallet boxes and in the conventional Florida field box. Another pertinent comparison is between pallet-box handling and the full bulk handling that is already practiced at a number of Florida packinghouses and on which there has been a 10-year research program (11, 12, and 13).

Although no direct comparison was made in this study, some aspects can be evaluated from experience and from the literature.

In comparison with a full bulk system, pallet-box handling has the following advantages:

(1) Smaller investment in the packinghouse. (Field-box degreening rooms can be readily adapted.)

(2) Using pallet boxes, a single system can be used both for large and for small groves, for long and short hauls, and for plantings of mixed varieties. Bulk handling calls for modified methods for such conditions (12).

(3) Various lots of fruit (by groves, by growers, by varieties, etc.) can easily be kept separate.

(4) Grove tractors equipped with forks during harvesting can be used during nonharvest periods without forks.

Pallet-box handling has the following disadvantages by comparison with full bulk handling:

(1) Fruit cannot be pregraded and presized prior to degreening without adding an additional handling to the operation.

(2) Forklift trucks (and drivers) are necessary for intrahouse transportation instead of using conveyors (however, movement of pallet boxes by floor-chain conveyors may ultimately be possible).

(3) Depreciation of pallet boxes may be much more rapid than for any equivalent bulk-handling equipment (11, 12). Of course, depreciation of: (a) Carts, (b) special small bulk-handling trucks, or (c) special truck elevator loaders must be considered with other methods. This equipment cannot be used during nonharvest periods.

LITERATURE CITED

(1) Grierson, W.
1957. The Effect of Pack-Out on Grower Profits. Fla. State Hort. Soc. Proc. 70: 21-28.

(2) _____ and Newhall, W. F.
1960. Degreening of Florida Citrus Fruits. Fla. Agr. Expt. Sta. Bul. 620, 80 pp., illus.

(3) _____ and Hayward, F. W.
1960. Precooling, Packaging, and Fungicides as Factors Affecting Appearance and Keeping Quality of Oranges in Simulated Transit Experiments. Am. Soc. Hort. Sci. Proc. 76: 229-239.

(4) _____, Hayward, F. W., and Oberbacher, M. F.
1959. Simulated Packing, Shipping, and Marketing Experiments With Valencia Oranges. Fla. State Hort. Soc. Proc. 72: 248-254.

(5) _____ and Oberbacher, M. F.
1959. Pack-Out as Affecting Profits of Citrus Packinghouses With Particular Reference to Fruit Color. Fla. State Hort. Soc. Proc. 72: 254-259.

(6) Herrick, Joseph F., Jr., McBirney, S. W., and Carlsen, E. W.
1958. Handling and Storage of Apples in Pallet Boxes. U. S. Dept. Agr. AMS-236, 41 pp., illus.
(7) Hopkins, E. F., and Loucks, K. W.
1953. An Improved Dowicide A-Hexamine Method for Decay Control in Citrus Fruits. Citrus Indust. 34 (10): 5-6, 13-14.
(8) _____ and McCornack, A. A.
1959. Methods for the Control of Decay in Oranges. Citrus Mag. 22 (4): 8, 10, and 30-31.
(9) _____ and McCornack, A. A.
1960. Effect of Delayed Handling and Other Factors on Rind Breakdown and Decay in Oranges. Fla. State Hort. Soc. Proc. 73: 263-269.
(10) Heebink, T. B.
1960. Rugged Tests for Bins. Prod. Mktg. 3 (3): 13-16.
(11) Phillips, R. V., and Grierson, W.
1955. Cost Advantages of Bulk Handling Through the Packinghouse. Fla. State Hort. Soc. Proc. 70: 171-177.
(12) _____ and Grierson, W.
1960. Cost Advantages of Bulk Handling. Fla. State Hort. Soc. Proc. 73: 231-235.
(13) Prosser, D. S., Jr., Grierson, W., Newhall, W. F., Thor, E., and Samuels, J. K.
1955. Bulk Handling of Fresh Citrus Fruits. Fla. State Agr. Expt. Sta. Bul. 564, 35 pp., illus.
(14) Spurlock, A. H.
1960. Cost of Picking and Hauling Florida Citrus Fruits. Fla. Agr. Expt. Sta. Agr. Econ. Mimeo Rpt. 60-9, 15 pp.
(15) _____ and Hamilton, G. H.
1960. Cost of Packing and Selling Florida Fresh Citrus Fruits. Fla. Agr. Expt. Sta. Agr. Econ. Mimeo Rpt. 60-10, 26 pp.
(16) Thor, Eric
1954. Cost Analysis of Bulk Handling Methods for Fresh Citrus. Fla. Agr. Expt. Sta. Agr. Econ. Mimeo Rpt. 55-1, 33 pp., illus.
(17) Tidbury, G. E.
1958. The Bulk Handling of Orchard Fruit. Commonwealth Agr. Bureau, Digest No. 1, 38 pp., illus.
(18) Yost, G. E., Bowman, E. K., Grierson, W., and Hayward, F. W.
1959. Degreening Citrus Fruits in Large Pallet Boxes. Citrus Mag. 21 (9): 10-11.

APPENDIX

Base Times

The base times, which are preliminary, for performing certain pallet-box handling operations with two types of forklift trucks are given in table 5. Descriptions and breakpoints for these operations follow:

Travel forward and reverse begins when forklift starts to travel in a forward or reverse direction. Includes traveling at maximum speed in a straight line and making large-radius turns. Time is measured in minutes per foot of linear travel. Ends when forklift stops traveling.

Table 5.--Base times (preliminary) for forklift truck operations used by cooperator for experimental pallet-box operations, 1959-60 1/

Time item	Walkie type		Narrow-aisle (reach type)	
	Empty	2,000 lbs.	Empty	2,000 lbs.
	Minutes	Minutes	Minutes	Minutes
Travel (per foot):				
Forward	.0047	.0055	.0032	.0036
Reverse	.0047	.0055	.0032	.0036
Accelerate:				
Forward	.010	.020	.010	.030
Reverse	--	--	.020	--
Stop:				
Forward	.010	.010	.010	.025
Reverse	--	--	--	.030
Run-in:				
1st level	.045	.056	--	--
2nd level	.103	--	--	--
3rd level	--	--	--	--
Run-out:				
1st level	.044	.055	--	--
2nd level	.044	--	--	--
3rd level	--	--	--	--
Tilt mast:				
Forward tilt	.120	.080	--	--
Backward tilt	--	.105	--	--
Hoist (per inch):				
Up	.0016	.0050	.0025	.0049
Down	.0010	.0020	.0027	.0028
Extend or retract forks	--	--	.050	.060
Turn 90° or with slow speed required:				
Forward	.082	.096	.056	.063
Reverse	.082	.096	.056	.063

1/ For turns that do not require slow speed, use distance involved and apply standard for forward travel. Fatigue allowance and personal allowance of 5 percent each must be added to base time values in developing productive time. Time values do not consider operating forklift equipment where there is insufficient space to work effectively, or where bridge-plates or floor are inadequate.

Accelerate begins when forklift starts to accelerate from a standstill. Includes starting from stop and reaching full speed. (This does not include the travel distance required to reach maximum speed.) Ends when the forklift has reached maximum operating speed.

Stop begins when forklift starts to slow from maximum speed. Includes slowing down and coming to complete stop. (This does not include the travel distance required to stop.) Ends when forklift has come to a complete stop.

Run-in first level begins when fork tips start to pass the face of the pallet or the pallet starts to pass the face of the set-down position. Includes the forks entering the pallet in preparation for picking up or the pallet entering the set-down position. Ends when forks have been completely inserted into the pallet or the pallet is in set-down position and the forklift has come to a complete stop. (This element also applies to run-in second or third levels.)

Run-out first level begins when forklift has picked up the pallet or has set the pallet down and is ready to back out. Includes reversing the forklift until the pallet clears the original set-down position or reversing the forklift until the forks clear the pallet. Ends when the pallet clears the face of the original position or the forks clear the pallet. (This element also applies to run-out second and third levels.)

Tilt (forward or backward) begins when mast of forklift starts to tilt either forward or backward. Includes forward or backward movement of the fork truck mast from a vertical angle of 90 degrees. Ends when the mast has been tilted to its desired position and stops.

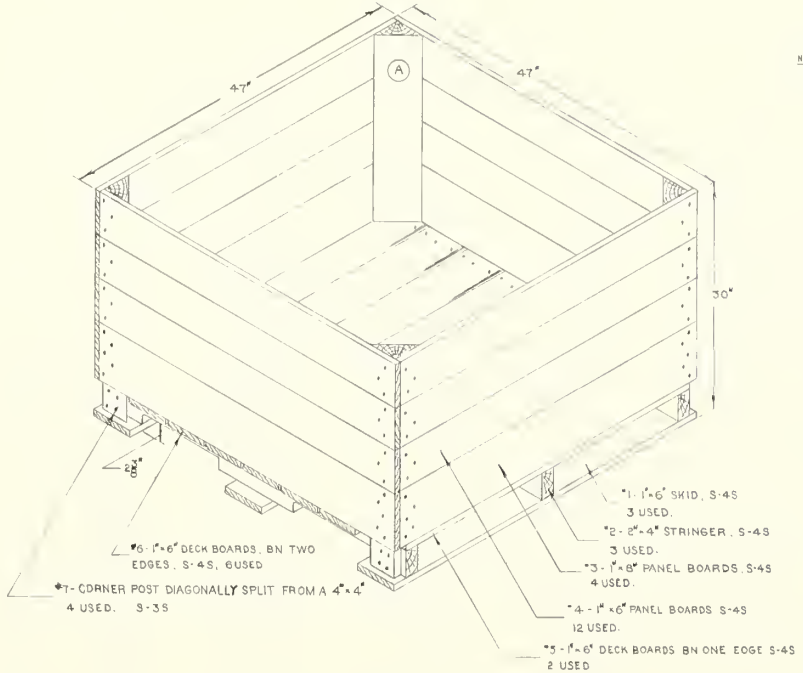
Hoist (up and down) begins when forks start to raise or lower. Includes raising or lowering the forks of the truck to the desired position. Time is measured in minutes per inch of travel with and without a load. Ends when the operator releases the control to stop the movement of the forks.

Extend or retract forks begins when forks start to extend or retract. Includes movement of the forks to either extend or retract with and without a load. Measured in minutes per occurrence. Ends when the forks have been completely extended or retracted and the operator releases the lever.

Turn 90 degrees or with slow speed required begins when forklift starts a 90-degree turn, or when travel speed is reduced to make other turns. Includes travel on the arc of a 90-degree turn, or travel with slow speed required on other turns. Ends when forklift completes a 90-degree turn, or when slow speed requirement ends for other turns.

Pallet Boxes Used In Tests

The pallet boxes used in the tests are illustrated in figures 15 to 20. These drawings show the details of the various boxes which were employed in the studies.



PART NUMBER	DESCRIPTION	QUANTITY	MATERIALS THICKNESS (INCHES)	WIDTH (INCHES)	LENGTH (INCHES)	FINISH
1	SKID BOARDS	3	1	6	47	S4S
2	STRINGER	3	2	4	47	S4S
3	PANEL BOARDS	4	1	8	46-3/8	S4S
4	PANEL BOARDS	12	1	6	46-3/8	S4S
5	DECK BOARDS	2	1	6	43-3/4	S4S B,N, 1 EDGE
6	DECK BOARDS	6	1	6	47	S4S B,N, 2 EDGES
7	CORNER POSTS (DIAGONALLY SPLIT)	4	4	4	29-3/8	S3S

NOTE: WOOD TO BE GRADE MARKED SOUTHERN YELLOW PINE (2 GRADE OR BETTER) OR GRADE MARKED CYPRESS (C GRADE OR BETTER) USE CEMENT COATED SCREW NAILS: 9d IN DECK BOARDS AND 6d IN ALL OTHERS - PATTERN AS SHOWN
B, N, = DULL NOSE EDGE FACE INSIDE FOR
S4S = SURFACE FOUR SIDES

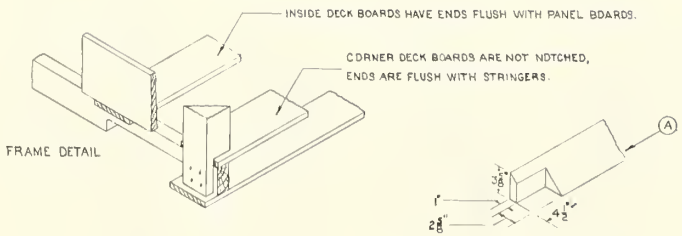
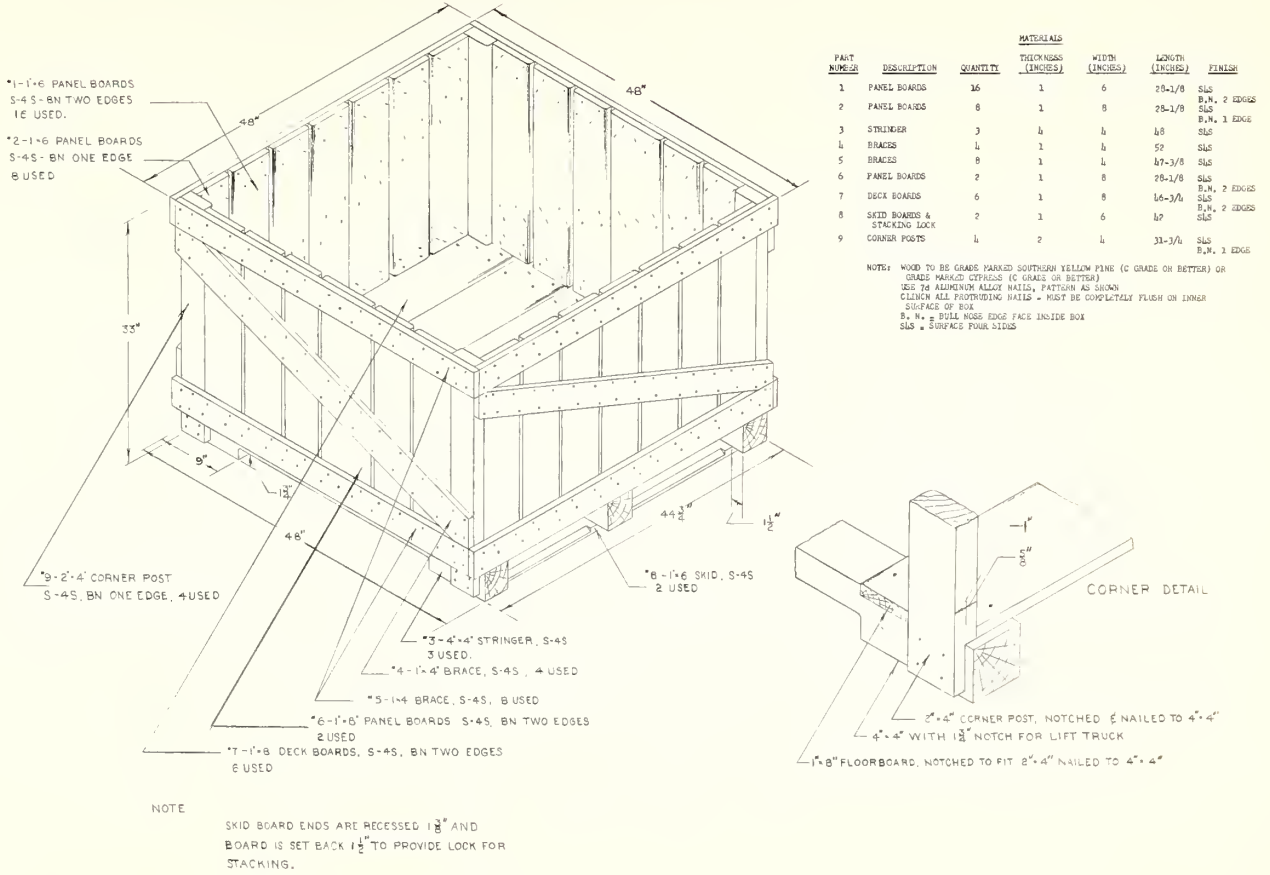


Figure 15.--Pallet box type A.



MATERIALS

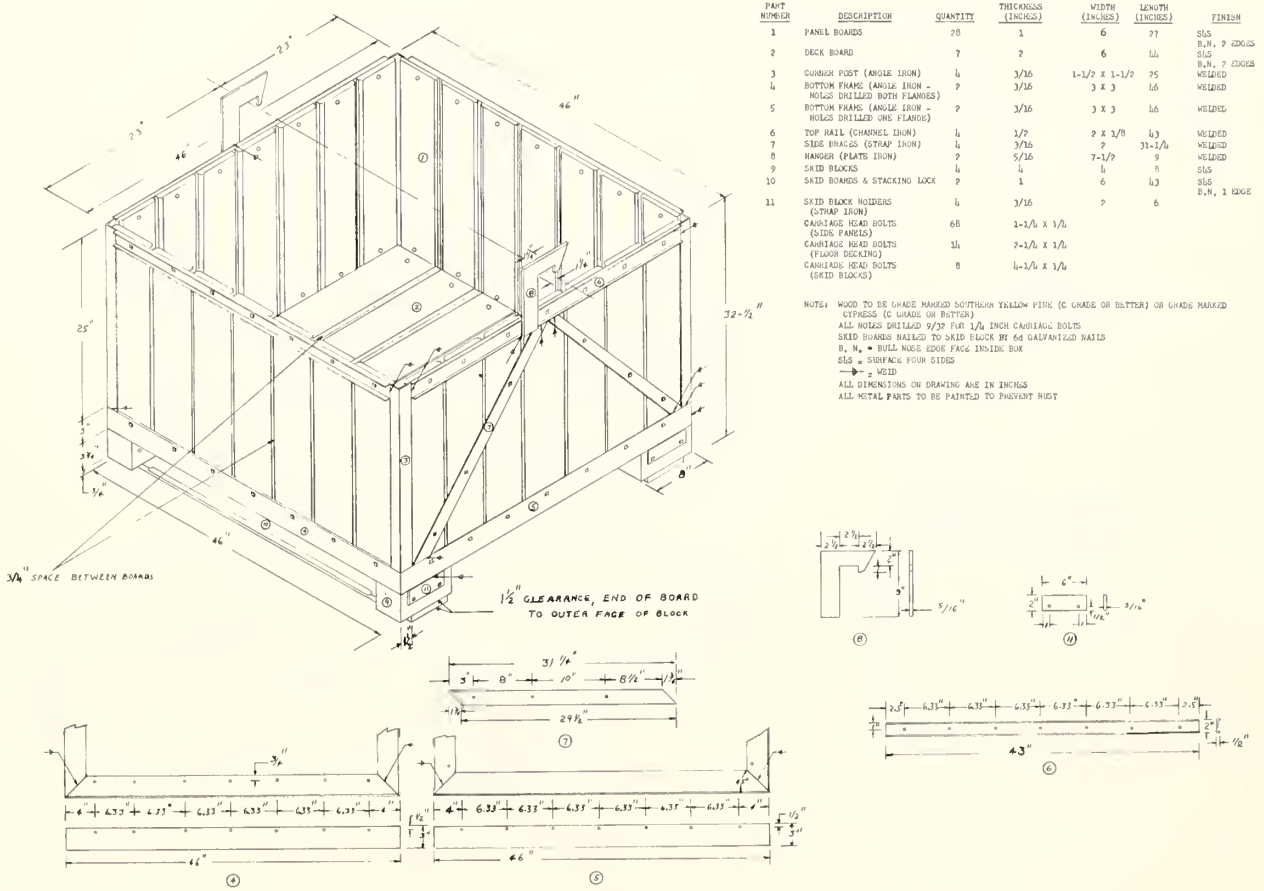
PART NUMBER	DESCRIPTION	QUANTITY	THICKNESS (INCHES)	WIDTH (INCHES)	LENGTH (INCHES)	FINISH
1	PANEL BOARDS	16	1	6	28-1/8	S4S
2	PANEL BOARDS	8	1	8	28-1/8	B.N. 2 EDGES S4S B.N. 1 EDGE
3	STRINGER	3	4	4	48	S4S
4	BRACES	4	1	4	52	S4S
5	BRACES	8	1	4	47-3/8	S4S
6	PANEL BOARDS	2	1	8	28-1/8	S4S B.N. 2 EDGES
7	DECK BOARDS	6	1	8	46-3/4	S4S B.N. 2 EDGES
8	SKID BOARDS & STACKING LOCK	2	1	6	42	S4S
9	CORNER POSTS	4	2	4	33-3/4	S4S B.N. 1 EDGE

NOTE: WOOD TO BE GRADE MARKED SOUTHERN YELLOW PINE (C GRADE OR BETTER) OR GRADE MARKED CYPRESS (C GRADE OR BETTER)
USE 7d ALUMINUM ALLOY NAILS, PATTERN AS SHOWN
CLINCH ALL PROTRUDING NAILS - MUST BE COMPLETELY FLUSH ON INNER SURFACE OF BOX
B. N. = BULL NOSE EDGE FACE INSIDE BOX
S4S = SURFACE FOUR SIDES

NOTE

SKID BOARD ENDS ARE RECESSED 1⅜" AND BOARD IS SET BACK 1½" TO PROVIDE LOCK FOR STACKING.

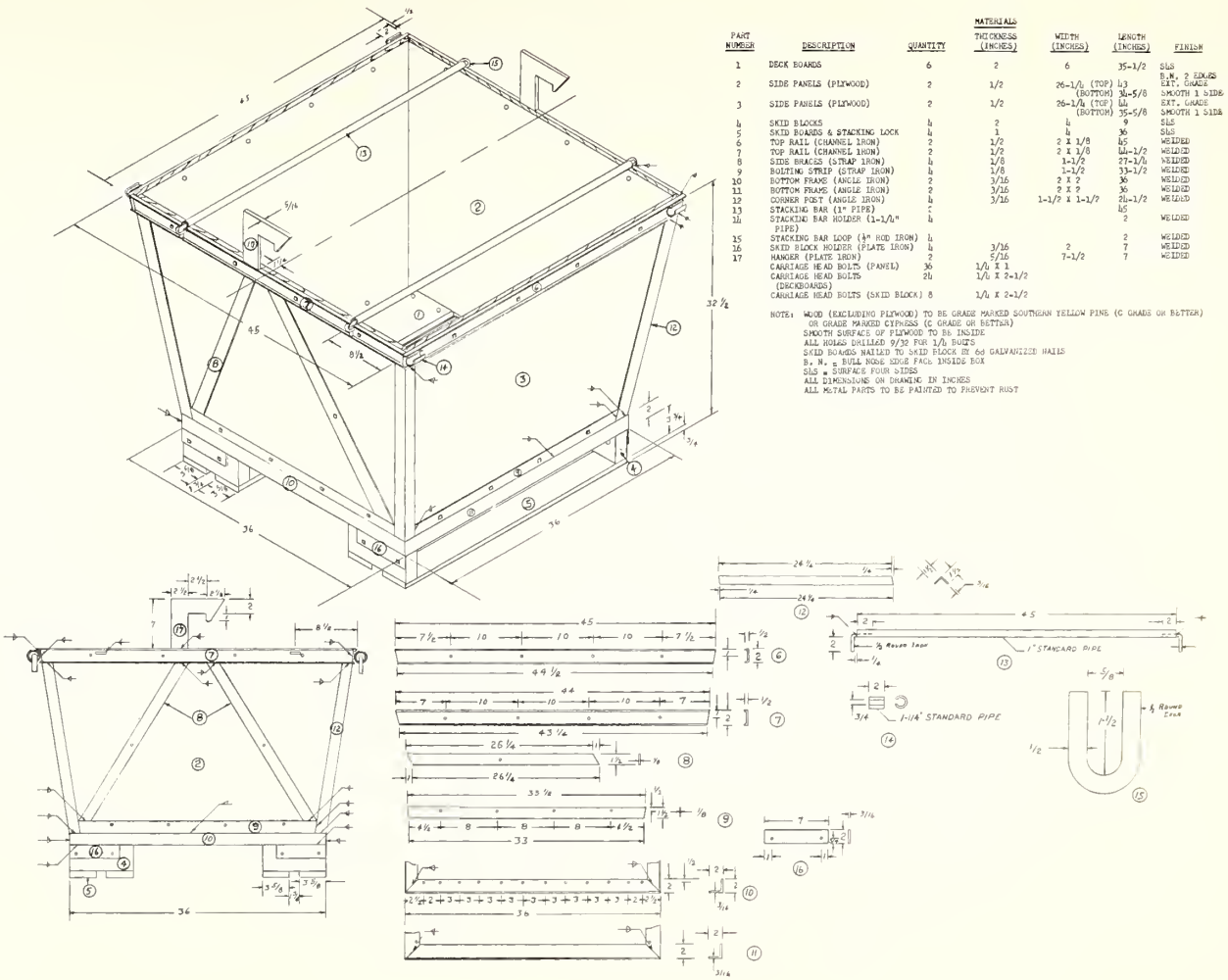
Figure 16.--Pallet box type B.



PART NUMBER	DESCRIPTION	QUANTITY	MATERIALS THICKNESS (INCHES)	WIDTH (INCHES)	LENGTH (INCHES)	FINISH
1	PANEL BOARDS	28	1	6	27	S4S B.N. 2 EDGES
2	DECK BOARD	7	2	6	44	S4S B.N. 2 EDGES
3	CORNER POST (ANGLE IRON)	4	3/16	1-1/2 X 1-1/2	25	WELDED
4	BOTTOM FRAME (ANGLE IRON - HOLES DRILLED BOTH FLANGES)	2	3/16	3 X 3	46	WELDED
5	BOTTOM FRAME (ANGLE IRON - HOLES DRILLED ONE FLANGE)	2	3/16	3 X 3	46	WELDED
6	TOP RAIL (CHANNEL IRON)	4	1/2	2 X 1/8	43	WELDED
7	SIDE BRACES (STRAP IRON)	4	3/16	2	31-1/4	WELDED
8	HANGER (PLATE IRON)	2	5/16	7-1/2	9	WELDED
9	SKID BLOCKS	4	4	4	8	S4S
10	SKID BOARDS & STACKING LOCK	2	1	6	43	S4S B.N. 1 EDGE
11	SKID BLOCK HOLDERS (STRAP IRON)	4	3/16	2	6	
	CARRIAGE HEAD BOLTS (SIDE PANELS)	68	1-1/4 X 1/4			
	CARRIAGE HEAD BOLTS (FLOOR DECKING)	14	2-1/4 X 1/4			
	CARRIAGE HEAD BOLTS (SKID BLOCKS)	8	4-1/4 X 1/4			

NOTE: WOOD TO BE GRADE MARKED SOUTHERN YELLOW PINE (C GRADE OR BETTER) OR GRADE MARKED CYPRESS (C GRADE OR BETTER)
ALL HOLES DRILLED 9/32 FOR 1/4 INCH CARRIAGE BOLTS
SKID BOARDS NAILED TO SKID BLOCK BY 6d GALVANIZED NAILS
B. N. = BULL NOSE EDGE FACE INSIDE BOX
S4S = SURFACE FOUR SIDES
→ = WELD
ALL DIMENSIONS ON DRAWING ARE IN INCHES
ALL METAL PARTS TO BE PAINTED TO PREVENT RUST

Figure 17.--Pallet box type C.



PART NUMBER	DESCRIPTION	QUANTITY	MATERIALS THICKNESS (INCHES)	WIDTH (INCHES)	LENGTH (INCHES)	FINISH
1	DECK BOARDS	6	2	6	35-1/2	SLS B.N. 2 EDGES
2	SIDE PANELS (PLYWOOD)	2	1/2	26-1/4 (TOP) 43 (BOTTOM)	34-5/8	EXT. GRADE SMOOTH 1 SIDE
3	SIDE PANELS (PLYWOOD)	2	1/2	26-1/4 (TOP) 44 (BOTTOM)	35-5/8	EXT. GRADE SMOOTH 1 SIDE
4	SKID BLOCKS	4	2	4	9	SLS
5	SKID BOARDS & STACKING LOCK	4	1	4	36	SLS
6	TOP RAIL (CHANNEL IRON)	2	1/2	2 X 1/8	45	WELDED
7	TOP RAIL (CHANNEL IRON)	2	1/2	2 X 1/8	44-1/2	WELDED
8	SIDE BRACES (STRAP IRON)	4	1/8	1-1/2	27-1/4	WELDED
9	BOLTING STRIP (STRAP IRON)	4	1/8	1-1/2	33-1/2	WELDED
10	BOTTOM FRAME (ANGLE IRON)	2	3/16	2 X 2	36	WELDED
11	BOTTOM FRAME (ANGLE IRON)	2	3/16	2 X 2	36	WELDED
12	CORNER POST (ANGLE IRON)	4	3/16	1-1/2 X 1-1/2	28-1/2	WELDED
13	STACKING BAR (1" PIPE)	2			45	
14	STACKING BAR HOLDER (1-1/4" PIPE)	4			2	WELDED
15	STACKING BAR LOOP (½" ROD IRON)	4			2	WELDED
16	SKID BLOCK HOLDER (PLATE IRON)	4	3/16	2	7	WELDED
17	HANGER (PLATE IRON)	2	5/16	7-1/2	7	WELDED
	CARRIAGE HEAD BOLTS (PANEL)	36	1/4 X 1			
	CARRIAGE HEAD BOLTS (DECKBOARDS)	24	1/4 X 2-1/2			
	CARRIAGE HEAD BOLTS (SKID BLOCK)	8	1/4 X 2-1/2			

NOTE: WOOD (EXCLUDING PLYWOOD) TO BE GRADE MARKED SOUTHERN YELLOW PINE (C GRADE OR BETTER) OR GRADE MARKED CYPRESS (C GRADE OR BETTER)
SMOOTH SURFACE OF PLYWOOD TO BE INSIDE
ALL HOLES DRILLED 9/32 FOR 1/4 BOLTS
SKID BOARDS NAILED TO SKID BLOCK IN 6d GALVANIZED NAILS
B. N. = BULL NOSE EDGE FACE INSIDE BOX
SLS = SURFACE FOUR SIDES
ALL DIMENSIONS ON DRAWING IN INCHES
ALL METAL PARTS TO BE PAINTED TO PREVENT RUST

Figure 18.--Pallet box type D.

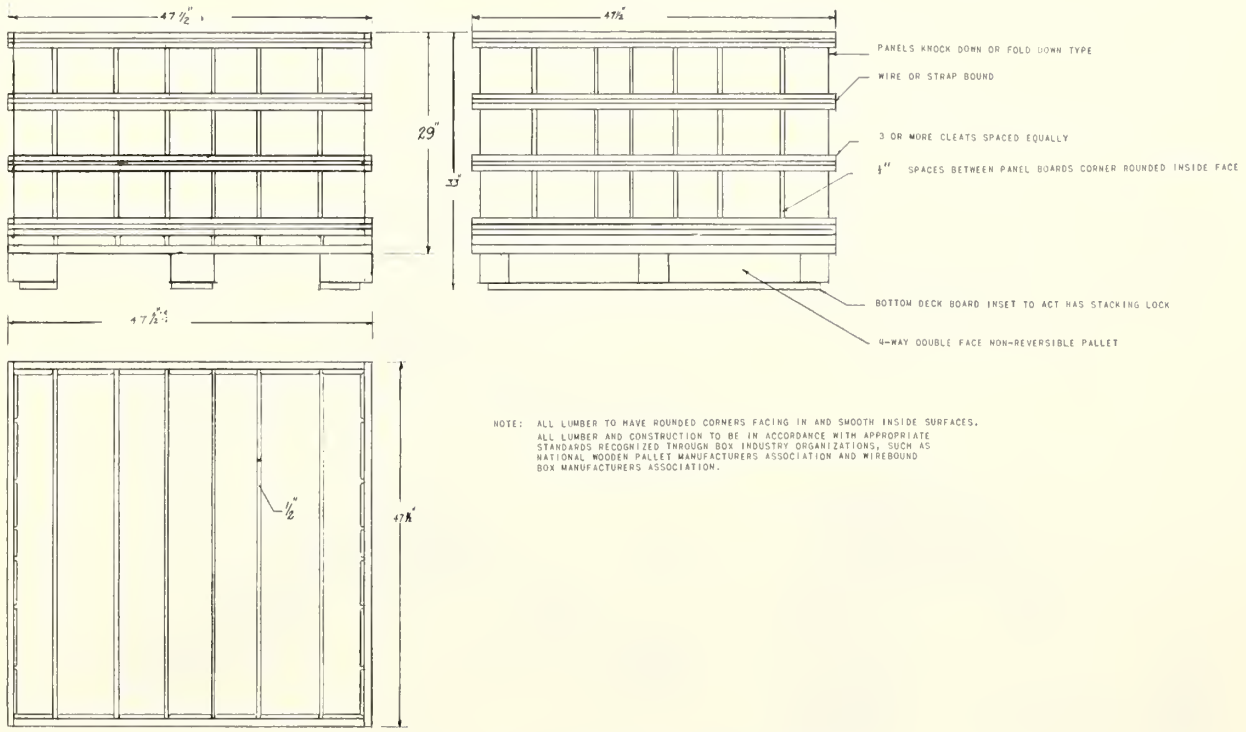
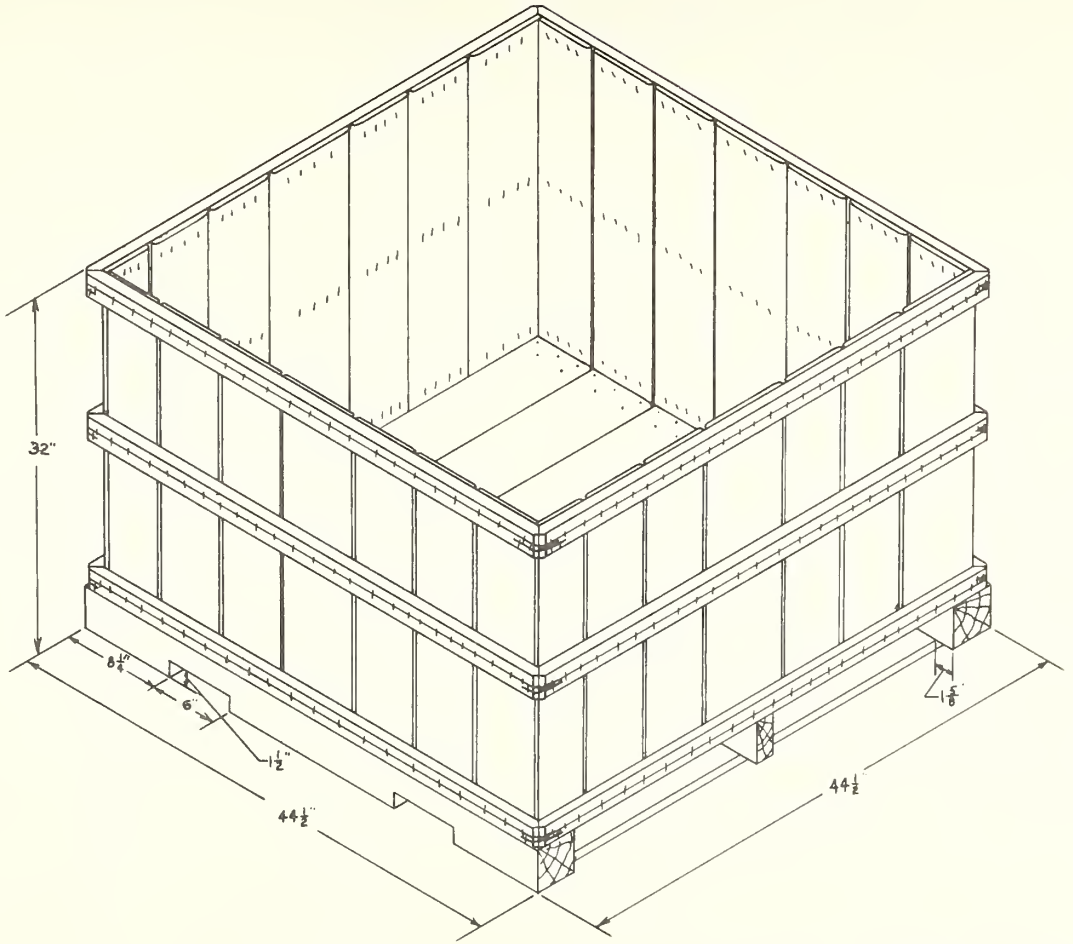


Figure 19.--Pallet box type E.



PALLET BOX, EXTERIOR CLEAT,
INSIDE DIMENSIONS - 42" X 42" X 26⅜"
REVERSE MITER CLEATS,
ROCK FASTENER CLOSURES,
FOUR WAY ENTRY,
FLOTATION STRIPS NAILED
PERPENDICULAR TO SKIDS AND SET
BACK FOR NESTING.

Figure 20.--Pallet box type F.

Data on Grove Tractors

Three types of tractors equipped with forklift attachments were used in the groves during the tests. Data and specifications of these tractors are presented in table 6.

Table 6.--Data on grove tractors used with forklift attachments

Specifications	Tractor A 1/	Tractor B 1/	Tractor C 1/
1. Front tires	7.50 x 16	7.50 x 16	9.00 x 16
2. Rear tires	15.00 x 23	15.00 x 23	14.00 x 24
3. Steering	Power	Power	Power
4. Accelerator	Foot-"shuttle" type	Foot and hand	Foot
5. Transmission	"Shuttle" type	Standard	Standard
6. Forklift	2	2	2
7. Capacity	3,000 lbs. each	3,000 lbs. each	3,000 lbs. each
8. Lifting height	6' 6"	6' 6"	6' 6"
9. Side shifter	On rear mast	On rear mast	On rear mast
10. Grove handling	Very satisfactory	Very satisfactory	Unsatisfactory
(a) Maneuverability	Best	Good 2/	Poor
(b) Horsepower	Sufficient	Sufficient	Insufficient
(c) Traveling	Good	Good 2/	Slow
(d) Speed	Ease of shifting	Wide range 3/	Hard to shift
(e) Seat	---	@ 45° for visibility-front and rear	---

1/ The data shown for this tractor apply only to the operations and conditions of this study, and do not apply to other uses and conditions.
2/ Front axle was truck type including springs.
3/ Had road gear for approximately 40 mph.

Labor and Equipment Costs

Labor and equipment costs for the different methods and different values are given in tables 7 through 13.

Table 7.--Estimated fixed or ownership costs of equipment

Type of equipment	Estimated replacement cost	Estimated salvage value	Estimated service life	Annual fixed cost			
				Depreciation	Licenses	Taxes, insurance and interest 1/	Total
	Dollars	Dollars	Years	Dollars	Dollars	Dollars	Dollars
Semitrailer truck tractor	7,500.00	500	8	875.00	185	375.00	1,435.00
Semitrailer truck trailer	3,500.00	250	12	270.83	165	175.00	610.83
Goat truck (flat bed)	2,500.00	0	5	500.00	60	125.00	685.00
Grove tractor	5,600.00	0	5	1,120.00	0	280.00	1,400.00
Forklift truck	4,500.00	0	8	562.50	0	225.00	787.50
Handtruck	90.00	0	12	7.50	0	4.50	12.00
Pallet-box dumper and installation	5,000.00	0	8	625.00	0	250.00	875.00
Pallet boxes	12.00	0	5	2.40	0	.60	3.00
Field boxes	2.50	0	3	.83	0	.13	.96
Field-box dumping machine	5,000.00	0	8	625.00	0	250.00	875.00
Empty field-box conveyor	4,000.00	0	8	500.00	0	200.00	700.00

1/ 5 percent of replacement cost.

Table 8.--Estimated annual fixed or ownership costs for the field-box method for four different weekly volumes

Type of equipment	Annual fixed cost per unit	Annual fixed costs at weekly volume of --							
		5,000 boxes		10,000 boxes		15,000 boxes		20,000 boxes	
		Units required	Costs	Units required	Costs	Units required	Costs	Units required	Costs
	Dollars	Number	Dollars	Number	Dollars	Number	Dollars	Number	Dollars
Goat truck	685.00	1	685.00	2	1,370.00	3	2,055.00	3	2,055.00
Semitrailer truck:									
Tractor	1,435.00	1	1,435.00	2	2,870.00	3	4,305.00	4	5,740.00
Trailer	610.83	3	1,832.49	5	3,054.15	7	4,275.81	9	5,497.47
Field-box dumper	875.00	1	875.00	1	875.00	1	875.00	1	875.00
Empty box conveyor	700.00	1	700.00	1	700.00	1	700.00	1	700.00
Field boxes	.96	4,000	3,840.00	8,000	7,680.00	12,000	11,520.00	16,000	15,360.00
Handtrucks	12.00	2	24.00	3	36.00	4	48.00	5	60.00
Total	--	--	9,391.49	--	16,585.15	--	23,778.81	--	30,287.47

Table 9.--Direct labor and equipment costs for the field-box method for four different weekly volumes

Job and equipment unit	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at a weekly volume of --			
				5,000 boxes	10,000 boxes	15,000 boxes	20,000 boxes
	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Labor:							
Picking foreman	8.88	1.35	--	11.99	11.99	11.99	11.99
Pickers	--	--	.18	180.00	180.00	180.00	180.00
Loaders	--	--	.045	45.00	45.00	45.00	45.00
Semitrailer truck driver	8.44	1.15	--	9.71	9.71	9.71	9.71
Handtrucks	1/	1.00	--	10.00	7.50	6.67	6.25
Field-box dumper operator	2/	1.00	--	5.00	2.50	1.67	1.25
Empty-box handler	5.62	1.00	--	5.62	5.62	5.62	5.62
Receiving foreman 3/	--	1.15	--	11.50	5.75	3.83	2.87
Payroll taxes 4/	--	--	--	19.52	18.76	18.51	18.39
Total	--	--	--	298.34	286.83	283.00	281.08
Equipment:							
Goat truck	9.56	.35	--	3.35	3.35	3.35	3.35
Semitrailer truck:							
Tractor	--	--	--	10.37	10.37	10.37	10.37
Trailer	--	--	--	1.84	1.84	1.84	1.84
Field-box dumper	2/	.093	--	.46	.23	.16	.12
Empty-box conveyor	2/	.049	--	.24	.12	.08	.06
Total	--	--	--	16.26	15.91	15.80	15.74
Total labor and equipment	--	--	--	314.60	302.74	298.80	296.82

1/ Computed as 10 hours per 1,000 boxes for 5,000 boxes per week; 7.5 for 10,000; 6.67 for 15,000; and 6.25 for 20,000.

2/ Computed as 5 hours per 1,000 boxes for 5,000 boxes per week; 2.5 for 10,000; 1.67 for 15,000; and 1.25 for 20,000.

3/ Assumes time of 10 hours per day.

4/ Computed at 7 percent of labor costs.

Table 10.--Estimated annual fixed or ownership costs for the pallet-box method (1 tractor) for four different weekly volumes

Type of equipment	Annual fixed cost per unit	Annual fixed costs at weekly volume of --							
		5,000 boxes		10,000 boxes		15,000 boxes		20,000 boxes	
		Units required	Costs	Units required	Costs	Units required	Costs	Units required	Costs
	Dollars	Number	Dollars	Number	Dollars	Number	Dollars	Number	Dollars
Grove tractor	1,400.00	1	1,400.00	2	2,800.00	3	4,200.00	4	5,600.00
Semitrailer truck:									
Tractor	1,435.00	1	1,435.00	2	2,870.00	3	4,305.00	3	4,305.00
Trailer	610.83	3	1,832.49	5	3,054.15	7	4,275.81	9	5,497.47
Fork truck	787.50	1	787.50	2	1,575.00	2	1,575.00	3	2,362.50
Pallet boxes	3.00	400	1,200.00	800	2,400.00	1,200	3,600.00	1,600	4,800.00
Pallet-box dumping and installation	875.00	1	875.00	1	875.00	1	875.00	1	875.00
Total	--	--	7,529.99	--	15,574.15	--	18,830.81	--	23,439.97

Table 11.--Direct labor and equipment costs for the pallet-box method (1 tractor) for four different weekly volumes

Job and equipment unit	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at a weekly volume of -- 5,000 boxes	10,000 boxes	15,000 boxes	20,000 boxes
	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Labor:							
Tractor driver--foreman	8.88	1.25	--	11.10	11.10	11.10	11.10
Pickers	--	--	.18	180.00	180.00	180.00	180.00
Semitrailer truck drivers	8.44	1.15	--	9.71	9.71	9.71	9.71
Fork-truck drivers	1/	1.00	--	5.00	5.00	3.47	3.75
Box-dumper operator	2/	1.00	--	5.00	2.50	1.67	1.25
Receiving foreman 3/	--	1.15	--	11.50	5.75	3.83	2.88
Payroll taxes 4/	--	--	--	15.56	14.98	14.68	14.61
Total	--	--	--	237.87	229.04	224.46	223.30
Equipment:							
Grove tractors	7.84	.40	--	3.14	3.14	3.14	3.14
Semitrailer trucks:							
Tractor	--	--	--	10.37	10.37	10.37	10.37
Trailer	--	--	--	1.84	1.84	1.84	1.84
Fork trucks	1/	.135	--	.68	.68	.47	.51
Box dumper	2/	.015	--	.08	.04	.03	.02
Total	--	--	--	16.11	16.07	15.85	15.88
Total labor and equipment	--	--	--	253.98	245.11	240.31	239.18

1/ Computed at 5 hours per 1,000 boxes for 5,000 boxes per week; 5 for 10,000; 3.47 for 15,000; and 3.75 for 20,000.

2/ Computed at 5 hours per 1,000 boxes for 5,000 boxes per week; 2.5 for 10,000; 1.67 for 15,000; and 1.25 for 20,000.

3/ Assumes time of 10 hours per day.

4/ Computed at 7 percent of labor costs.

Table 12.--Estimated annual fixed or ownership costs for the pallet-box method (2 tractors) for four different weekly volumes

Type of equipment	Annual fixed cost per unit	Annual fixed costs at weekly volume of --							
		5,000 boxes		10,000 boxes		15,000 boxes		20,000 boxes	
		Units required	Costs	Units required	Costs	Units required	Costs	Units required	Costs
	Dollars	Number	Dollars	Number	Dollars	Number	Dollars	Number	Dollars
Grove tractor	1,400.00	2	2,800.00	4	5,600.00	6	8,400.00	8	11,200.00
Semitrailer truck:									
Tractor	1,435.00	1	1,435.00	2	2,870.00	3	4,305.00	4	5,740.00
Trailer	610.83	3	1,832.49	5	3,054.15	7	4,275.81	9	5,497.47
Fork truck	787.50	1	787.50	2	1,575.00	2	1,575.00	3	2,362.50
Pallet boxes	3.00	400	1,200.00	800	2,400.00	1,200	3,600.00	1,600	4,800.00
Pallet-box dumping installation	875.00	1	875.00	1	875.00	1	875.00	1	875.00
Total	--	--	8,929.99	--	16,374.15	--	23,030.81	--	30,474.97

Table 13.--Direct labor and equipment costs for the pallet-box method (2 tractors) for four different weekly volumes

Job and equipment unit	Hours per 1,000 boxes	Rate per hour	Piece rate per box	Cost per 1,000 boxes at a weekly volume of --			
				5,000 boxes	10,000 boxes	15,000 boxes	20,000 boxes
	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Labor:							
Tractor driver--foreman	8.88	1.25	--	11.10	11.10	11.10	11.10
Tractor driver	8.88	1.00	--	8.88	8.88	8.88	8.88
Pickers	--	--	.18	180.00	180.00	180.00	180.00
Semitrailer truck drivers	8.44	1.15	--	9.71	9.71	9.71	9.71
Fork truck drivers	1/	1.00	--	5.00	5.00	3.47	3.75
Box dumper operator	2/	1.00	--	5.00	2.50	1.67	1.25
Receiving foreman 3/	--	1.15	--	11.50	5.75	3.83	2.88
Payroll taxes 4/	--	--	--	16.18	15.61	15.31	15.23
Total	--	--	--	247.37	238.55	233.97	232.80
Equipment:							
Grove tractors	10.29	.40	--	4.12	4.12	4.12	4.12
Semitrailer trucks:							
Tractor	--	--	--	10.37	10.37	10.37	10.37
Trailer	--	--	--	1.84	1.84	1.84	1.84
Fork trucks	1/	.135	--	.68	.68	.47	.51
Box dumper	2/	.015	--	.08	.04	.03	.02
Total	--	--	--	17.09	17.05	16.83	16.86
Total labor and equipment	--	--	--	264.46	255.60	250.80	249.66

1/ Computed at 5 hours per 1,000 boxes for 5,000 boxes per week; 5 for 10,000; 3.47 for 15,000; and 3.75 for 20,000.

2/ Computed at 5 hours per 1,000 boxes for 5,000 boxes per week; 2.5 for 10,000; 1.67 for 15,000; and 1.25 for 20,000.

3/ Assumes time of 10 hours per day.

4/ Computed at 7 percent of labor costs.

Simulated Shipping Tests

Results of simulated shipping tests are presented in tables 14 through 19. These tests furnish comparative data for fruit handled by the different systems, indicating the amount of decay that would be found in fruit under commercial operating conditions. Various stages in the marketing process, such as, "at retail sale," and "after one week in consumer's home," are covered.

Table 14.--Decay studies with early oranges picked November 16 and packed November 20, 1959

Sample		Decay at 10 days 1/ (= "retail sale")			Decay at 17 days 2/ (= 1 week in customer's home)		
No.	Description	SER 3/	Pen. 4/	Total	SER 3/	Pen. 4/	Total
		Percent	Percent	Percent	Percent	Percent	Percent
1	From field, degreened in mesh bag.....	15.8	0	15.8	21.1	0	21.1
2	Before degreening, from top of Box 2, then degreened in a field box.	11.4	4.2	15.6	30.2	4.2	34.4
3	Before degreening, from bottom of Box 66, then degreened in a field box.	17.8	4.2	22.0	34.7	7.4	42.1
4	After degreening sample (top to bottom) Box 60...	13.5	0	13.5	37.5	1.0	38.5
5	After degreening sample (top to bottom) Box 66...	9.8	5.4	15.2	16.3	7.6	23.9

1/ 6 days at 60° F. ("refrigerated transit") plus 4 days at 70° F.
2/ 7 more days at 70° F.
3/ SER - stem-end rot.
4/ Pen. - Penicillium (green and blue molds).

Table 15.--Decay studies with midseason oranges picked December 2 and packed December 4, 1960

Sample		Decay at 10 days 2/ (= "retail sale")			Decay at 17 days 3/ (= 1 week in customer's home)		
No. 1/	Description	SER 4/	Pen. 5/	Total	SER 4/	Pen. 5/	Total
		Percent	Percent	Percent	Percent	Percent	Percent
A-1	Degreened in mesh bag in N.W. corner	0	0	0	0	0	0
A-2	Degreened in mesh bag East side of N.W. stack	0	0	0	6.5	0	6.5
A-3	From pallet box No. 3, leaving dumper, before bulk receiving bin (type A)	5.0	2.5	7.5	6.3	2.5	8.8
A-4	From pallet box No. 3, leaving bulk bin (type A)	5.0	5.0	10.0	19.0	7.5	26.5
A-5	From pallet box No. 38, leaving dumper, before bulk receiving bin (type B)	1.2	2.4	3.6	7.2	4.8	12.0
A-6	From pallet box No. 38, leaving bulk bin (type B)	0	5.2	5.2	5.2	6.6	11.8
B-1	From tops of stacked field boxes just arriving from grove	0	0	0	7.5	1.1	8.6
B-2	Entering bulk bins	1.0	2.0	3.0	2.0	3.2	5.2

1/ Samples numbered A were oranges picked in pallet boxes and clearly identifiable (degreened) and samples numbered B were oranges arriving in field boxes and being run into bulk bins (not degreened).

2/ 6 days at 60° F. ("refrigerated transit") plus 4 days at 70° F.

3/ 7 more days at 70° F.

4/ SER - stem-end rot.

5/ Pen. - *Penicillium* (green and blue molds).

Table 16.--Decay studies with midseason oranges (variety dubious, probably Pineapple) picked January 8 and packed January 11, 1960

Pallet box type	Sample taken	Decay at 10 days 1/ (= "retail sale")			Decay at 17 days 2/ (= 1 week in customer's home)		
		SER 3/	Pen. 4/	Total	SER 3/	Pen. 4/	Total
		Percent	Percent	Percent	Percent	Percent	Percent
A	Before dumping	28.5	20.8	49.3	44.9	26.2	71.1
B	do. do.	34.8	15.6	50.4	54.6	19.0	73.6
C	do. do.	17.2	25.0	42.2	33.9	31.4	65.3
D	do. do.	--	--	--	--	--	--
E	do. do.	27.1	23.8	50.9	44.7	33.4	78.1
F	do. do.	29.6	18.3	47.9	53.4	28.3	81.7
Average		27.4	20.7	48.1	46.3	27.7	74.0
Check	Before dumping	14.4	17.5	31.9	44.7	24.1	68.8
A	After dumping	22.5	28.1	50.6	38.6	39.8	78.4
B	do. do.	32.8	21.8	54.6	51.5	30.8	82.3
C	do. do.	11.4	27.9	39.3	33.6	44.7	78.3
D	do. do.	--	--	--	--	--	--
E	do. do.	31.5	25.5	57.0	52.9	28.0	80.9
F	do. do.	27.7	32.1	59.8	42.3	43.1	85.4
Average		25.2	27.1	52.3	43.8	37.3	81.1

1/ 6 days at 60° F. ("refrigerated transit") plus 4 days at 70° F.
2/ 7 more days at 70° F.
3/ SER - stem-end rot.
4/ Pen. - Penicillium (green and blue molds).

Table 17.--Decay studies with midseason oranges (variety dubious, possibly Pineapple) picked January 26 and packed January 27, 1960

Pallet box type	Sample taken	Decay at 10 days 1/ (= "retail sale")			Decay at 17 days 2/ (= 1 week in customer's home)		
		SER 3/	Pen. 4/	Total	SER 3/	Pen. 4/	Total
		Percent	Percent	Percent	Percent	Percent	Percent
A	Before dumping	4.3	29.2	33.5	26.1	46.6	72.7
B	do. do.	12.1	35.9	48.0	24.4	61.1	85.5
C	do. do.	4.8	39.5	44.3	27.4	56.3	83.7
D	do. do.	--	--	--	--	--	--
E	do. do.	5.2	20.8	26.0	35.2	32.1	67.3
F	do. do.	10.8	22.2	33.0	37.5	38.9	71.4
Average		7.4	29.5	36.9	28.1	47.0	76.1
A	After dumping	6.4	33.3	39.7	25.8	50.5	76.3
B	do. do.	--	--	--	--	--	--
C	do. do.	8.0	41.3	49.3	25.3	57.3	82.6
D	do. do.	--	--	--	--	--	--
B & C	do. do.	8.4	42.1	50.5	25.3	61.4	86.7
E & F	do. do.	1.1	23.8	24.9	40.5	32.1	72.6
Average		6.0	35.1	41.1	29.2	50.3	79.5

1/ 6 days at 60° F. ("refrigerated transit") plus 4 days at 70° F.
2/ 7 more days at 70° F.
3/ SER - stem-end rot.
4/ Pen. - Penicillium (green and blue molds).

Table 18.--Decay studies with midseason oranges (varieties Pineapple, Homosassa and Seedling) picked January 25 and packed January 26, 1960

Pallet box type	Sample taken	Decay at 10 days 1/ (= "retail sale")			Decay at 17 days 2/ (= 1 week in customer's home)		
		SER 3/	Pen. 4/	Total	SER 3/	Pen. 4/	Total
		Percent	Percent	Percent	Percent	Percent	Percent
A	Before dumping	3.5	34.0	37.5	30.8	41.6	72.4
B	do. do.	25.0	27.2	52.2	40.0	32.4	72.4
C	do. do.	6.7	34.6	41.3	24.3	43.0	67.3
D	do. do.	--	--	--	--	--	--
E	do. do.	22.3	25.2	47.5	45.2	28.6	73.8
F	do. do.	.6	20.5	21.1	32.5	28.3	60.8
Average		11.6	28.3	39.9	34.5	34.8	69.3
Field box (Check)	Before dumping	4.9	27.2	32.1	32.1	33.3	65.4
		5.4	10.9	16.3	32.7	16.4	49.1
Average		5.1	19.1	24.2	32.4	24.9	57.3
A & E 5/	After dumping	16.1	20.5	36.6	40.2	25.0	65.2
B	do. do.	4.0	23.8	27.8	21.8	42.6	64.4
C & F 5/	do. do.	10.2	27.3	37.5	34.1	36.4	70.5
F	do. do.	4.3	24.6	28.9	44.9	31.9	76.8
Average		8.6	24.1	32.7	35.3	33.9	69.2

1/ 6 days at 60° F. ("refrigerated transit") plus 4 days at 70° F.
2/ 7 more days at 70° F.
3/ SER - stem-end rot.
4/ Pen. - Penicillium (green and blue molds).
5/ Some unintentional blending of fruit from 2 types of boxes while samples being taken.

Table 19.--Decay studies with Valencia oranges picked April 20 and packed April 21, 1960

Sample		Decay at 10 days 1/ (= "retail sale")			Decay at 17 days 2/ (= 1 week in customer's home)		
No.	Description	SER 3/	Pen. 4/	Total	SER 3/	Pen. 4/	Total
		Percent	Percent	Percent	Percent	Percent	Percent
1	Random sample taken from trees by research personnel.....	0	0	0	7.7	0	7.7
2	Random sample taken from tops of pallet boxes after loading on semitrailer.....	0	0	0	4.9	1.6	6.5
Average		0	0	0	6.3	.8	7.1
3	From pallet boxes at rear of trailer on arrival; from various depths in two pallet boxes.....	1.9	0	1.9	13.5	3.8	17.3
4	After dumper; random sample from pallet boxes 13 and 83 (Types A and E).....	0	0	0	15.8	3.5	19.3
5	After bulk receiving bin; from boxes 13 and 83.....	1.4	1.4	2.8	8.7	5.8	14.5
Average		1.6	.7	2.3	12.7	3.4	21.0

1/ 6 days at 60° F. ("refrigerated transit") plus 4 days at 70° F.
2/ 7 more days at 70° F.
3/ SER - stem-end rot.
4/ Pen. - Penicillium (green and blue molds).

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